DOCUMENT RESUME

ED 124 734 CE 009 500

TITLE	Engine Lathe Operator. Instructor's Guide. Part of Single-Tool Skills Program Series. Machine Industries Occupations.
INSTITUTION	New York State Education Dept., Albany. Bureau of Continuing Education Curriculum Development.; New York State Education Dept., Albany. Bureau of Secondary Curriculum Development.
PUB DATE	72
NOTE	167p.; For related documents see CE 009 501
EDRS PRICE	MF-$0.83 HC-$8.69 Plus Postage.
DESCRIPTORS	Adult Education; *Curriculum; Curriculum Guides; Hand Tools; *Industrial Education; Instructional Materials; Job Skills; *Machine Tool Operators; *Machine Tools; Metals; Metal Working Occupations; Post Secondary Education; Secondary Education; *Skill Development; Student Projects; Vocational Education

ABSTRACT

Expected to help meet the need for trained operators in metalworking and suitable for use in the adult education programs of school districts, in manpower development and training programs, and in secondary schools, this guide consists of four sections: Introduction, General Job Content, Shop Projects, and Drawings for the Projects. General Job Content lists the content outline in the left column and teaching points and techniques in the right column. The 16 names of shop projects and drawings for the projects include Multi-Diameter Shaft, Ball Peen Hammer, Die Wrench, Fly Tool Face Cutter, Self-Centering Vise, Close Quarter, Hacksaw, Bench Vise, Lathe Dieholder, Eccentric Test Shaft, Tap Wrench, Micrometer Boring Head, Surface Gage, Arbor Press, Lathe Mandrel, Lathe Center and Morse Taper, and Grinding Vise. Sixteen job sheets for the shop projects are included. The top section of each job sheet includes operator's job title, project name, time needed, and related drawing number, performance objectives, operations, equipment, and materials needed. The bottom section of the job sheet has two columns--the left column lists the procedure and the right column lists the techniques and related information. (HD)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED134734

Engine Lathe Operator

INSTRUCTOR'S GUIDE

Part of
SINGLE-TOOL SKILLS PROGRAM
MACHINE INDUSTRIES OCCUPATIONS

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Bureau of Continuing Education Curriculum Development
Bureau of Secondary Curriculum Development
Albany, New York 12224
1972

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

CE 009 500

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University (with years when terms expire)

1984 Joseph W. McGovern, A.B., LL.B., L.H.D., LL.D., D.C.L.
Chancellor- New York
1985 Everett J. Penny, B.C.S., D.C.S., Vice Chancellor - - - - White Plains
1978 Alexander J. Allan, Jr., LL.D., Litt.D. - - - - - - - - - - Troy
1973 Charles W. Millard, Jr., A.B., LL.D., L.H.D.- - - - - - - - Buffalo
1987 Carl H. Pforzheimer, Jr., A.B., M.B.A., D.C.S., H.H.D.- - Purchase
1975 Edward M. M. Warburg, B.S., L.H.D.- - - - - - - - - - - - New York
1977 Joseph T. King, LL.B. - - - - - - - - - - - - - - - - - - - Queens
1974 Joseph C. Indelicato, M.D.- - - - - - - - - - - - - - - - - Brooklyn
1976 Mrs. Helen B. Power, A.B., Litt.D., L.H.D., LL.D. - - - - - Rochester
1979 Francis W. McGinley, B.S., LL.B., LL.D. - - - - - - - - - - Glens Falls
1980 Max J. Rubin, LL.D., L.H.D. - - - - - - - - - - - - - - - - New York
1986 Kenneth B. Clark, A.B., M.S., Ph.D., Litt.D.- - - - - - - - Hastings on Hudson
1982 Stephen K. Bailey, A.B., B.A., M.A., Ph.D., LL.D. - - - - - Syracuse
1983 Harold E. Newcomb, B.A. - - - - - - - - - - - - - - - - - - Owego
1981 Theodore M. Black, A.B., Litt.D.- - - - - - - - - - - - - - Sands Point

President of the University and Commissioner of Education
Ewald B. Nyquist

Executive Deputy Commissioner of Education
Gordon M. Ambach

Deputy Commissioner for Elementary, Secondary, and Continuing Education
Thomas D. Sheldon

Associate Commissioner for Instructional Services
Philip B. Langworthy

Assistant Commissioner for Instructional Services (General Education)
Bernard F. Haake

Director, Division of School Supervision
Gordon E. Van Hooft

Chief, Bureau of Secondary Curriculum Development

Chief, Bureau of Continuing Education Curriculum Development
Herbert Bothamley

Assistant Commissioner for Occupational Education
Robert S. Seckendorf

Director, Division of Occupational Education Instruction
Robert H. Bielefeld

Chief, Bureau of Trade and Technical Education
Carl G. Benenati

Foreword

The Engine Lathe Operator course contained in this book is intended to help fill the need for men trained to operate machine tools. The backgrounds of those who enter the course will very likely cover a broad range of qualifications, but it is likely that many men with little education or experience will be included. Completion of this course alone, obviously will not make anyone a full-fledged machinist.

This course is the first to be published in what we hope will be a series of instructor's guides in the Single-Tool Skills Program. Although written primarily as an adult course it is also quite suitable for use at the secondary school level. It was produced as a joint project of the two curriculum bureaus named on the title page.

The Single-Tool Skills Program is one of the programs in a broad plan covering machine industries occupations. The original plan was conceived by Robert S. Hunter, former associate in the Bureau of Trade and Technical Education. A number of teachers were involved in the overall planning for machine industries occupations, and also wrote material for the course guides. They are: Elek D. Csont, Seneca Vocational High School, Buffalo; Jack Grossman, Alexander Hamilton High School, Brooklyn; Alfred Kagan, Sewanhaka High School, Floral Park; Gilbert Pultz, Jefferson Vocational and Technical Center, Watertown; William G. Stewart, North Senior High School, Binghamton; William F. Tiedemann, Central Technical High School, Syracuse; and Joseph Waldinsperger, College of Continuing Education, Rochester Institute of Technology, Rochester.

Other members of the State Education Department took part in the overall planning, and in the further detailed planning which resulted in the production of this publication. They are E. Noah Gould, associate in the Bureau of Continuing Curriculum; G. Earl Hay, supervisor in the Bureau of Secondary Curriculum; and Edward Shattuck and Charles A. Stebbins, both associates in the Bureau of Trade and Technical Education.

Messrs. Kagan, Pultz, Stewart, Tiedemann, and Waldinsperger wrote the Engine Lathe Operator course contained in this booklet. Mr. Gould directly supervised the writing and edited the manuscript.

HERBERT BOTHAMLEY, *Chief*
Bureau of Continuing Education
Curriculum Development

GORDON E. VAN HOOFT, *Director,*
Division of School Supervision

Message to the Instructor

This Engine Lathe Operator course is expected to help meet the need for trained operators in metalworking. The course is suitable for use in the adult education programs of school districts, in Manpower Development and Training programs, and in secondary schools.

Anyone who completes this course successfully will be qualified for an entry-level job as operator of an engine lathe. After completing the course some students may go on to other single-tool courses and become qualified to operate more than one machine tool. It is even possible that a student with outstanding ability, by completing the courses for several machine tools, could become a machinist.

The 16 shop projects in this course are listed on pages vi and vii. There is no requirement that any student complete all projects, or even all jobs within any project. The instructor may determine which projects a given student should complete, and may, if he wishes, use projects other than those included in this book.

The teacher for this course would ideally be a person with not only good training and experience in machinist skills, but also several years of teaching experience. The best sources from which to draw such teachers are the faculties of schools giving machine tool courses, and from the ranks of those employed as machinists, and supervisors of machinists.

Adult Education Directors, Occupational Education Directors, and teachers who have any questions or comments should direct them to either the Bureau of Trade and Technical Education or to one of the Bureaus named on the title page.

CARL G. BENENATI, *Chief*
Bureau of Trade and
Technical Education

ROBERT H. BIELEFELD, *Director*
Division of Occupational Education

Contents

	Page
Foreword	iii
Message to the Instructor	iv
List of Shop Projects	vi
List of Drawings for Shop Projects	viii
List of Drawings and Jobs Covered on Each	ix
INTRODUCTION	1
GENERAL JOB CONTENT	4
JOB SHEETS FOR SHOP PROJECTS	12
BIBLIOGRAPHY	80
DRAWINGS FOR SHOP PROJECTS	81

MACHINE INDUSTRIES OCCUPATIONS
SINGLE-TOOL SKILLS PROGRAM
ENGINE LATHE OPERATOR COURSE

SHOP PROJECTS

Project No.		Time (hrs.)	Page
I.	Multi-diameter shaft		
	Job 1. Step turning (rule sizes)	15	13
	Job 2. Step turning (micrometer sizes)	7	15
	Job 3. Knurled chamfered shaft	4	16
	Job 4. Die threading and undercutting	2	17
	Job 5. Thread turning	5	18
II.	Ball peen hammer		
	Job 1. Handle	12	19
	Job 2. Cap	4	21
	Job 3. Head	6	23
	Job 4. Pin	½	25
III.	Die Wrench		
	Job 1. Body	5	26
	Job 2. Handle	7	28
IV.	Fly tool face cutter		
	Job 1. Body	3½	30
V.	Self-centering vise		
	Job 1. Jaw-actuating screw	7	32
	Job 2. Guide rod	1	34
	Job 3. Knurled handle	3	35
VI.	Close quarters hacksaw		
	Job 1. Frame	1	37
	Job 2. Handle	6	38
	Job 3. Adjustable blade retainer	2	40
	Job 4. Pin	½	42
VII.	Bench vise		
	Job 1. Nut	3	43
	Job 2. Washer	2	44
	Job 3. Handle	4	45
	Job 4. Guide pin	1	46
	Job 5. Fixed and movable jaws	4	47
	Job 6. Screw	6	49
VIII.	Lathe dieholder		
	Job 1. Sliding holder	8	50
	Job 2. Tapered shank support	12	52

Project No.	Time (hrs.)	Page
IX. Eccentric test shaft		
Job 1. Shaft	30	54
X. Tap wrench		
Job 1. Chuck body	8	57
Job 2. Wrench body	10	59
Job 3. Handle	$\frac{1}{2}$	61
XI. Micrometer boring head		
Job 1. Stop pin	$\frac{1}{2}$	62
Job 2. Dial	4	63
Job 3. Shank	4	64
Job 4. Dovetail slide	3	65
XII. Surface gage		
Job 1. Adjustment screw	1	66
Job 2. Scriber point	$1\frac{1}{2}$	67
XIII. Arbor press		
Job 1. Rack pad	2	68
Job 2. Table	2	69
Job 3. Sleeve	3	70
Job 4. Gear shaft	3	71
Job 5A & 5B. Handle and end	$3\frac{1}{2}$	72
Job 6. Column	8	74
XIV. Lathe mandrel		
Job 1. Mandrel	3	75
XV. Lathe center, Morse taper		
Job 1. Lathe center, No. 3 Morse taper	4	76
XVI. Grinding vise		
Job 1. Lead screw nut	$2\frac{1}{2}$	77
Job 2. End nut	2	78
Job 3. Lead screw	3	79
Total time for shop projects	230	

MACHINE INDUSTRIES OCCUPATIONS
SINGLE-TOOL SKILLS PROGRAM
ENGINE LATHE OPERATOR COURSE

DRAWINGS FOR SHOP PROJECTS

DWG. NO.	TITLE OF DRAWING	Page
1	Multi-Diameter Shaft: Step Turning, Rule & Micrometer Sizes	82
2	Multi-Diameter Shaft: Knurled Chamfered Shaft	83
3	Multi-Diameter Shaft: Die Threading & Undercutting	84
4	Multi-Diameter Shaft: Thread Turning	85
5	Ball Peen Hammer: Assembly	86
6	Ball Peen Hammer: Details	87
7	Die Wrench	88
8	Fly Tool Face Cutter	89
9	Self-Centering Vise: Assembly	90
10	Self-Centering Vise: Jaw-Actuating Screw	91
11	Self-Centering Vise: Guide Rod	92
12	Self-Centering Vise: Knurled Handle	93
13	Close Quarters Hacksaw: Assembly	94
14	Close Quarters Hacksaw: Details	95
15	Bench Vise: Assembly	96
16	Bench Vise: Details	97
17	Bench Vise: Fixed and Movable Jaws	98
18	Lathe Dieholder: Sliding Holder	99
19	Lathe Dieholder: Tapered Shank Support	100
20	Eccentric Test Shaft	101
21	Tap Wrench	102
22	Micrometer Boring Head: Assembly	103
23	Micrometer Boring Head: Dial, Shank, and Stop Pin	104
24	Micrometer Boring Head: Dovetail Slide	105
25	Surface Gage: Assembly	106
26	Surface Gage: Details	107
27	Arbor Press: Assembly	108
28	Arbor Press: Gear Shaft, Rack Pad, and Rack	109
29	Arbor Press: Table	110
30	Arbor Press: Sleeve, Table Pin, and Cover Plate	111
31	Arbor Press: Handle and End	112
32	Arbor Press: Column	113
33	Arbor Press: Base	114
34	Lathe Mandrel	115
35	Lathe Center, Morse Taper	116
36	Grinding Vise: Assembly	117
37	Grinding Vise: Lead Screw Nut	118
38	Grinding Vise: Lead Screw and End Nut	119

MACHINE INDUSTRIES OCCUPATIONS
SINGLE-TOOL SKILLS PROGRAM
ENGINE LATHE OPERATOR COURSE

DRAWINGS AND JOBS COVERED ON EACH

DRAWING NUMBER	PROJECT No.	PROJECT NAME	LATHE JOBS COVERED	Page
1	I	Multi-Diameter Shaft	1,2	82
2			3	83
3			4	84
4			5	85
5	II	Ball Peen Hammer	1,2,3,4	86
6			1,2,3,4	87
7	III	Die Wrench	1,2	88
8	IV	Fly Tool Face Cutter	1	89
9	V	Self-Centering Vise	1,2,3	90
10			1	91
11			2	92
12			3	93
13	VI	Close Quarters Hacksaw	1,2,3,4	94
14			1,2,3,4	95
15	VII	Bench Vise	1,2,3,4,5,6	96
16			1,2,3,4,6	97
17			5	98
18	VIII	Lathe Dieholder	1	99
19			2	100
20	IX	Eccentric Test Shaft	1	101
21	X	Tap Wrench	1,2,3	102
22	XI	Micrometer Boring Head	1,2,3,4	103
23			1,2,3	104
24			4	105
25	XII	Surface Gage	1,2	106
26			1,2	107
27	XIII	Arbor Press	1,2,3,4,5,6	108
28			1,4	109
29			2	110
30			3	111
31			5	112
32			6	113
33			Base	114
34	XIV	Lathe Mandrel	1	115
35	XV	Lathe Center, Morse Taper	1	116
36	XVI	Grinding Vise	1,2,3	117
37			1	118
38			2,3	119

Introduction

As shown in the Contents, the Engine Lathe Operator course consists of this Introduction, General Job Content (which explains what the operator's job includes), Shop Projects, and the drawings for the projects.

The job for which the trainee would be qualified upon completion of this course is referred to in the Dictionary of Occupational Titles (under the code number 604.280) as engine lathe setup operator, tool; precision lathe operator; and toolroom lathe operator. Another applicable job title is lathe operator, production, (machine shop), code number 604.885.

The general objective of the course is to train men, in a comparatively short time, to be placed as engine lathe operators. The course is not intended to give a broad training in metalworking, but only the skill to operate one kind of metalworking machine. By keeping the objective narrow, the training time is kept to a minimum, and the trainees are made available for work without a long delay.

Since one important purpose of this course is to help those with a minimum of background, the prerequisites for admission should be broad enough so none will be barred who could be made employable. The operating authorities for each program, school, and school district determine the prerequisites for this course, and can adapt them to any special local conditions.

The *minimum* prerequisites we suggest for a trainee (and they are not mandatory) are that he have enough ability to understand and follow the course instructions (*either* written *or* oral), so he can produce the simplest workpiece included in the course. Such a trainee will, perhaps, be able to qualify only as a production machine operator, where all the machine setups are made for him. Another trainee with more background will possibly qualify for jobs requiring more skill, such as engine lathe setup operator or toolroom lathe operator.

We believe that enough general information about the job and more than enough shop projects are included for the trainee to reach the general objective of the course. All essential engine lathe skills are used in the shop projects a number of times. The schools may use everything in the course, they may select only some of the material, they may make changes in it, and they may use other material not contained here. They may also determine the length of the class periods, their frequency, and the total amount of time to be spent in training. For those that need a guide: A typical night class runs 2½ to 3 hours, either once or twice a week, for 30 weeks.

In some of the shop projects of this course the workpieces are not completed because operations are required on metalworking machines other then the engine lathe. The other single-tool courses which we hope to produce will, when published, provide for the additional operations.

The drawings in this course are numbered serially, beginning with No. 1. When any other single-tool courses are published the drawings in them will continue the same series of numbers. The shop projects in the other courses

may also refer back to the drawings in the Engine Lathe Operator course. In fact, some of the drawings included with this course require no engine lathe operations, but, for convenience, are included here with other drawings of an assembly requiring some lathe work.

Drawings 34 and 35 contain tables giving several different sets of dimensions for the workpieces pictured. These permit the instructor to select the set of dimensions which he finds best for each student or for the conditions under which his class operates. As a shop project is assigned to a student, we recommend that the instructor give him a copy of the Job Sheet and applicable drawings. In the drawings, all dimensions are in inches unless otherwise indicated.

Each drawing has four blocks for information at the bottom, with the one at the upper right blank. We suggest that the instructor have the student write the numbers of the project and job for which he is using the drawing, in that blank space. Each Job Sheet has the words *Unit No.* in the upper left corner, but no number is given. The instructor may wish to write a number in this space to fit in with his own method of organizing his classroom and shop work.

The Job Sheets show two references which are especially recommended for the machine work. The bibliography gives the complete citations for these two books and also contains additional references.

Following are the abbreviations used in the text and drawings of this course.

ACT.	actuate	HEX.	hexagonal
ACTG.	actuating	HT.	height
ALUM.	aluminum	LG.	long
ASSY.	assembly	LGTH.	length
CHAM.	chamfer	MATL.	material
CBORE.	counterbore	MED.	medium
CRS	cold rolled steel	PT.	part
CSK.	countersink	R or RAD.	radius
DIA.	diameter	REQD.	required
DP.	deep	R.H.	right-hand
DP	diametral pitch	SCR.	screw
DR.	drill	SOC.	socket
DR or DR. ROD	drill rod	SPEC.	specifications
EQ. SP.	equally spaced	SPHER.	spherical
FAO	finish all over	STL.	steel
HD	head	SQ.	square
HDL.	handle	TYP.	typical
HGT.	height	W.	width

General Job Content

CONTENT OUTLINE		TEACHING POINTS AND TECHNIQUES
I.	Types of Machines	Discuss the various types of lathes, such as: bench type, toolroom precision, and geared head.
II.	Machine Parts	Give the names, locations, and uses of the various parts of the lathe, for example: bed, headstock, and carriage.
III.	Machine Accessories A. Tool holders	Establish familiarity with standard tool holding devices, including: 1. standard tool-bit holder 2. standard boring bar holder 3. cut-off tool holder Note that the tool post grinder may be used to do many operations, such as internal and angle grinding.
	B. Work holders	Identify the work holding devices, such as: chucks, collets, and steady rests.
IV.	Cutting Tools	Mention the different kinds of cutting tools, some of which are: cutoff, tool-bit, and circular form relief thread. Discuss the tool in terms of clearance, rake angle, and chip groove. Demonstrate the procedures in grinding and sharpening the various cutting tools.
V.	Measurement and Inspection	List and explain the various types of measuring tools. Some of these are: micrometer, indicator, telescoping gage, and vernier height gage.
VI.	Bluepring Reading	Introduce and cover all necessary blueprint reading. For example: 1. theory of orthographic projection 2. language of lines 3. sectional views 4. tolerance 5. finishing symbols
VII.	Speeds and Feeds	Emphasize the importance of speeds and feeds relative to machining time, cutter life, and finish. Point out that different materials require different cutting speeds based on the kind of cutting tool material used. For example: A carbide cutting tool can machine cast iron at 210-450 feet per minute and brass at 600-900 feet

CONTENT OUTLINE		TEACHING POINTS AND TECHNIQUES
		per minute. A high speed cutting tool can machine soft cast iron at 70-170 feet per minute and brass at 200-300 feet per minute. Calculate the r.p.m. of a piece of work based on the material being machined, the diameter of the work, and the material in the cutting tool. For example: What r.p.m. should a lathe revolve at in order to machine a 2-inch diameter piece of brass that is machined at 300 feet per minute? The formula is: $\text{r.p.m.} = \frac{\text{SFMx4}}{\text{DIA.}} = \frac{300\text{x4}}{2} = \frac{1200}{2}$ $= 600$ r.p.m. Make available charts and tables which will enable the student to select proper speeds and feeds for a particular job. Note that speeds are expressed as advance in inches per revolution of work. Note further that optional feed is correlated to the depth of cut and the finish required.
VIII.	Trade Mathematics	Introduce and cover all necessary trade mathematics, such as basic arithmetic, constants, and formulas.
IX.	Coolants	Explain that the use of coolants or cutting oils will increase tool life and give a better finish on the work. Point out that each different material requires a different type of cutting fluid. Some cutting fluid categories are: 1. straight mineral oils 2. soluble oils (water emulsions) 3. chemical-water mixtures (synthetic)
X.	Care and Maintenance	Call attention to the fact that the accuracy of the work depends on the proper care and maintenance of the machine. Observe some rules such as 1. Level the lathe properly. 2. Oil the lathe properly. 3. Thoroughly clean the ways. Explain further that the care of small tools is very important in the development of a good workman. Some rules are:

CONTENT OUTLINE		TEACHING POINTS AND TECHNIQUES
		1. Keep tapered shanks clean. 2. Do not use a wrench as a hammer. 3. Avoid hitting reamer edges against other metal.
XI.	Safety	Introduce the personal safety rules that must be used when operating the machine: 1. Wear close fitting clothes. 2. Wear safety glasses. 3. Make sure all guards are in place. 4. Keep hands away from moving parts. Demonstrate how to avoid particular dangers, such as: 1. Use pliers to remove chips entwined on the workpiece or the cutting tool. 2. Use a cradle on the bed or a bar through the spindle when mounting and removing chucks. 3. Remove chuck keys from the chuck *immediately* after use. 4. Remove, protect, or position tool bits safely away when setting up or measuring a job. 5. Support long pieces before running at high speeds. 6. If a long piece extends from the back of the spindle, tie a rag around it. However, long thin diameters are dangerous in any case. 7. Turn the machine by hand for a complete revolution after setting up. 8. When you hear unusual noises from your machine, stop it and find out what is causing them.
XII.	Trade Terms	Explain all trade terms peculiar to the trade, for example: *gib*—a wedge-shaped strip that can be adjusted to maintain a proper fit between movable surfaces of a machine tool
XIII.	Work Processes	
	A. Facing	Explain that facing is one of the first operations usually done on the engine lathe. Illustrate some of the turning or facing tools that may be used for this operation. Demonstrate that facing can be done by holding work: in the chuck, between centers, or in both chuck and steady rest.

CONTENT OUTLINE	TEACHING POINTS AND TECHNIQUES
B. Center drilling	State that center drilling with a combination drill and countersink is done to prevent a twist drill from wandering when starting to drill a hole in the end of a piece of work. Also that center drilling might also be done to make permanent center holes in order to mount the piece of work between centers. Emphasize that when center drilling for permanent center holes, the size of the combination drill and countersink should be in proportion to the diameter of the work piece. For example: A No. 3 combination drill and countersink should be used to drill a $\frac{3}{16}$-inch diameter hole in the end of a 1-inch diameter work piece. Call attention to the fact that when long pieces are to be center drilled, one method that may be used is the use of both chuck and steady rest.
C. Drilling	Explain that drilling is an operation that machines a round hole in a piece of work to a desired depth. Indicate further that the twist drill is usually held in the tail stock spindle by means of a drill chuck or drill socket. Emphasize that a standard drill will not finish a hole to precision requirements. Point out that the core drill is used to enlarge an existing hole that does not require the characteristics of a reamed hole.
D. Reaming	Mention that reaming is done to make a hole: round, straight, or tapered, or sized to precision dimensions. Indicate further that the drilled hole, prior to reaming, must be drilled undersize. For example: 1. Drill a hole .120" in diameter for a $\frac{1}{8}$" reamer. 2. Drill a hole .368" in diameter for a $\frac{3}{8}$" reamer. 3. Drill $\frac{1}{64}$" undersize for holes over $\frac{3}{8}$" diameter. State that reamers and drills are held in the same way.
E. Straight turning	Define straight turning as an operation by a turning tool for reducing the outside diameter of a piece of work to a given diameter.

CONTENT OUTLINE	TEACHING POINTS AND TECHNIQUES
	Discuss the important points for the proper set-up during straight turning. Some examples are: 1. Position of the tool post 2. Position of the lathe dog 3. Trueness of the headstock center Emphasize that chip control is important and should be handled by means of a proper chip groove, ground on the tool so as to curl and break the chips. Elaborate on the use of the steady rest and the follower rest for long slender work. Discuss the method and problems involved in machining an eccentric such as a crankshaft. Some examples include laying out more than one set of center holes, and using braces to avoid bending the work pieces. Emphasize that turning usually requires roughing and finishing cuts.
F. Shoulder turning	Explain that a shoulder is a point at which two diameters meet. State further that there are several types of shoulders which require different shaped tools. Two of these are filleted corner and chamfered. Elaborate on the procedure in facing a square shoulder. For example, give details on roughing out the material in the corner, and amount of material that should be left for finishing.
G. Taper turning	List the different methods of machining a taper, such as by use of taper attachment and compound rest. Point out the importance of setting the cutting tool on center. Explain that due to the extreme accuracy and high quality of work required today, the offset method of cutting a taper should be discouraged, except for special situations.
H. Boring	Explain that boring is done to enlarge and/or true a hole. Emphasize the importance of using a short, large boring bar to overcome such problems as chatter and bell-mouthed holes.
I. Threading	Call attention to the fact that external threads can be cut by chasing with a single-pointed tool or by use of a die. State further that threads

CONTENT OUTLINE	TEACHING POINTS AND TECHNIQUES
	can be chased internally by means of a boring bar or by use of thread tap. Emphasize the importance of locating the thread tool on center and aligning it properly. Describe the procedure in chasing left-hand and multiple threads.
J. Knurling	Define knurling as a means of rolling depressions in the surface of a piece of work. Explain the problems involved when knurling. For example: bending of small work and double tracking.
K. Forming	Define form turning as machining special shapes by means of tools formed to the desired outline. State further that forming or contour turning can be done with a single-point tool by manipulating both the carriage and crossfeed handwheels. Emphasize the importance of: location of the tool, proper speeds, and proper coolants. Explain the method of filing and polishing work as it revolves.
L. Grooving	Emphasize that the following trade terms are used interchangeably with the term grooving: recess, relief, and undercut. Explain a few of the reasons for grooving, such as: 1. To run out space for a thread tool at a shoulder 2. To avoid a fillet on a ground shaft Add that grooving can be done internally as well as externally. Elaborate on the fact that the width of the grooving tool depends on the particular job. Some factors are size of the thread that is being chased, and amount of stock that is left for grinding.
M. Cutting off	Emphasize the proper setup for the cutting-off operation such as having the tool on center and at a right angle to the work. Mention the problems involved in using a cutoff tool, such as chatter and breakage.

CONTENT OUTLINE	TEACHING POINTS AND TECHNIQUES
N. Backing-off	Demonstrate the procedure in setting up a backing-off attachment. Make the necessary calculations in order to set the lathe for the proper degree of clearance on a cutter that is to be backed-off.
O. Filing	Demonstrate moving a single-cut file across a revolving workpiece by taking long even strokes for: 1. removing burrs and rounding edges 2. blending-in form cut outlines 3. fitting parts Stress the safety procedures when using the left-hand filing method.
P. Polishing	Note that this operation sometimes is used to produce a fine finish with strips of abrasive cloth contacting round work that is revolving at high speeds. Explain that the finer the abrasive, the finer the resulting finish, and that a machine oil lubricant sometimes is used to improve the finish.

Job Sheets for Shop Projects

Unit No. *Operator's job title:* Engine lathe operator

Project I *Project Name:* Multi-diameter shaft

Job No. 1 *Job name:* Step turning (rule sizes) *D.O.T. No.* 604.280

Drawing No. 1 *Time:* 15 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Straight turning
4. Shoulder turning
5. Layout

Equipment:

Engine lathe	Tool bits
3-jaw chuck	Center drill
Drill chuck	6" and 12" rules
Lathe centers	Scriber
Lathe dog	Calipers
Drive plate	Layout dye

Materials
Hot rolled steel
SAE 1018, $1\frac{3}{4}$" dia. x $6\frac{1}{2}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and remove sharp edges.	1. Review safety rules.
2. Mount 3-jaw chuck and locate work in chuck.	2. Refer to III B and IV in content outline.
3. Face end to clean up.	
4. Mount chuck and center drill in tailstock and machine center hole in part.	
5. Remove from chuck and layout overall length.	5. Use layout dye, combination square and scriber, or surface plate and surface gage with scriber.
6. Remount in chuck, face to layout line and center drill.	6. Do not face beyond layout line.
7. Remove chuck and mount lathe centers and drive plate.	7. Check lathe center alignment.
8. Attach lathe dog and mount workpiece between centers.	8. Check clearance between lathe dog tail and drive-plate slot. Use proper tension for tailstock center and lubricate if necessary.
9. Rough turn "A" diameter up to lathe dog.	9. Set calipers with steel rule graduations and practice feel on standard size piece.

PROCEDURE	TECHNIQUES AND RELATED INFO.
10. Finish turn "A" diameter to caliper setting.	
11. Remove lathe dog and layout length of dia. A.	11. Use layout dye.
12. Mount lathe dog on dia. A, locate between centers, rough turn "B" dia. to layout line.	12. Use copper or other soft metal to protect turned dia. from dog.
13. Layout and rough turn each diameter to length.	13. Use subtraction to find distances of shoulders from each other for chucking.
14. Finish turn all diameters to caliper size and length.	14. Use a sharp pointed tool to finish shoulders square.
15. Remove all sharp edges, recheck measurements, and submit for inspection and grade.	15. Use left-hand filing for safety near lathe dog.

Unit No. *Operator's job title:* Engine lathe operator

Project I *Project Name:* Multi-diameter shaft

Job No. 2 *Job name:* Step turning (micrometer sizes) *D.O.T. No.* 604.280

Drawing No. 1 *Time:* 7 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Straight turning
2. Shoulder turning
3. Micrometer reading

Equipment:

Engine lathe	Toolholder
Lathe centers	Tool bits
Drive plate	6" rule
Lathe dog	1" and 2" micrometer

Materials
Hot rolled steel
SAE 1018, from
Job No. 1, Project No. 1

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Clamp lathe dog on diameter G at small end of workpiece.	
2. Mount between centers and turn A diameter to size.	2. Start a trial cut and check size with micrometer. Make necessary adjustments to finished size.
3. Remove workpiece and relocate dog on A diameter.	3. Use soft metal to protect finished surface.
4. Turn B diameter to size and square shoulder.	4. Take trial cut and check with micrometer and make necessary adjustments to hold correct size.
5. Turn each diameter to size using same method.	5. Check center tension and lubrication if necessary.
6. Remove sharp edges with a file.	
7. Recheck dimensions and submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project I *Project Name:* Multi-diameter shaft

Job No. 3 *Job name:* Knurled chamfered shart *D.O.T. No.*604.280

Drawing No. 2 *Time:* 4 hours

Objectives

Using the equipment,materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Straight turning
2. Chamfering
3. Knurling
4. Layout

Equipment:

Engine lathe
Lathe centers
Drive plate
Lathe dog
Tool bits
6" rule
1" and 2" micrometers

Materials

Same piece of hot rolled steel SAE 1018 as used on Jobs 1 and 2,Project No. 1.

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by Mc Carthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Place dog on small end and mount between centers. Turn large end to $1\frac{1}{8}$" dia., $2\frac{1}{4}$" long.	1. Stress cleaning spindles before setting up lathe centers. Check alignment of tailstock.
2. Knurl with medium pitch knurling tool.	2. Point out that knurling setup is square to work-piece and knurling rolls centered on center line of work.
3. Set lathe compound to 45° and chamfer end.	3. Remind students that cutting tool height is on center line.
4. Reverse dog and turn middle section to $\frac{7}{8}$" dia.	4. Protect knurled surface with soft material under dog.
5. Knurl with medium pitch knurling tool.	5. Point out need for proper pressure and lubricant.
6. Turn small end to $\frac{9}{16}$" dia.	
7. Knurl with fine pitch knurling tool.	
8. Set compound and cut required chamfers on two shoulders and end.	8. Differentiate between compound settings for angles.
9. Hand in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project I *Project Name:* Multi-diameter shaft

Job No. 4 *Job name:* Die threading and under-cutting *D.O.T. No.* 604.280

Drawing No. 3 *Time:* 2 hrs.

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Straight turning
2. Undercutting
3. Chamfering
4. Threading with split adjustable die

Equipment:

Engine lathe	Tool bits
Lathe centers	$\frac{1}{2}$"-13 die and die stock
Drive plate	6" rule
Lathe dog	1" micrometer
3-jaw chuck	Test nut

Materials
Same piece of hot-rolled steel SAE 1018 as used on Jobs 1, 2, 3 of Project No. 1

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Place dog on small end, set between centers and turn large end to $\frac{3}{4}$" dia., $4\frac{1}{32}$" long.	1. Review correct procedure for setting up lathe for straight turning.
2. Reverse dog and turn $\frac{9}{16}$" dia. to .500-.499" dia., $2\frac{7}{32}$" long.	2. Introduce finish turning to close tolerance
3. Set tool and make undercut to depth.	3. Use thread formulas for minor diameter of thread.
4. Set up chamfering tool bit to 45° angle and form chamfer on end.	4. Stress that the tool bit must be on center for proper cutting action.
5. Remove work and centers and mount 3-jaw chuck. Chuck on $\frac{3}{4}$" dia.	
6. Start die on $\frac{1}{2}$" dia. turning the spindle by hand.	6. Show setup for holding die stock backed up by tail-stock spindle. Stress using cutting oil for threading steel.
7. Remove work from lathe and clamp in bench vise to finish die cut thread by hand.	7. Point out method of breaking off chips by backing up a half-turn. Use oil.
8. Remove sharp edges and turn in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project I *Project Name:* Multi-diameter shaft

Job No. 5 *Job name:* Thread turning *D.O.T. No.* 604.280

Drawing No. 4 *Time:* 5 hrs.

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Straight turning
2. Chamfering
3. Undercutting
4. Threading with single point tool
5. Facing
6. Center drilling

Equipment:

Engine lathe	Tool bits
Lathe centers	6" rule
Drive plate	1" micrometer
Lathe dog	Thread micrometer (11-pitch)
3-jaw chuck	Center gage

Materials
Same piece of hot-rolled steel SAE 1018 as used on Jobs 1, 2, 3, 4 of Project No. 1

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Clamp stock in bench vise and saw off $\frac{1}{2}$" dia. threaded end at the undercut.	
2. Mount in 3-jaw chuck and face and center drill.	2. Review importance of proper center hold size.
3. Attach dog, set up lathe centers and drive plate, turn stock to size.	
4. Chamfer end to 45°.	4. Use protractor or combination square head to set tool bit.
5. Reverse dog and finish turn other end.	
6. Set up tool bit and cut $\frac{3}{16}$" undercut.	6. Use thread formulas for depth of undercut.
7. Set up chamfering tool and chamfer end.	
8. Set compound at 30° and adjust threading tool bit to correct height and alinement.	8. Introduce center gage and properly ground threading tool bit.
9. Adjust speed to slow and set gears to 11 threads per inch.	9. Demonstrate use of chart for correct lead and use of thread chasing dial.
10. Cut threads to proper depth using compound infeed.	10. Use thread manual for correct pitch diameter. Check with thread micrometer. Formula for compound infeed: $\frac{.75}{N}$
11. Remove sharp edges and hand in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project II *Project Name:* Ball peen hammer

Job No. 1 *Job name:* Handle *D.O.T. No.* 604.280

Drawing Nos. 5,6 *Time:* 12 hrs.

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Straight turning
4. Taper turning
5. Knurling
6. Drilling
7. Tapping
8. Polishing

Equipment:
Engine lathe
Collet assembly
Lathe tool bits
Drills
Tap
Drill chuck
Fine knurling tool

Materials
24 ST aluminum, $\frac{3}{4}$" dia. x $8\frac{1}{4}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount collet assembly with $\frac{3}{4}$" collet. Fasten workpiece with drawbar allowing $\frac{1}{2}$" stock to project.	
2. Set lathe tool for facing and face both ends. Finish to length as per drawing.	
3. Center drill both ends.	
4. Place stock on centers and drive with lathe dog	4. Discuss use of soft material between workpiece and dog to prevent marring.
5. Set lathe tool for turning.	
6. Remove .010-.015 from section D. Turn to 4" length.	6. Point out that workpiece must run true before knurling.
7. Fine knurl to fit $\frac{3}{4}$" collet.	7. Elaborate on knurling technique to avoid double tracking.
8. Layout section B and C lengths.	
9. Mount collet assembly with $\frac{3}{4}$" collet. Fasten section A with drawbar and support knurl end with center.	
10. Arrange lathe to obtain taper using taper attachment.	10. Demonstrate use of the taper attachment.
11. Set $\frac{1}{8}$" radius lathe tool for taper turning and take light trial cut over section C.	

PROCEDURE	TECHNIQUES AND RELATED INFO.
12. Caliper at both ends of section C to test accuracy of taper. If taper is not correct adjust setting to correct error.	
13. Rough turn tapered section C.	
14. Finish turn tapered section C as per drawing.	
15. Arrange lathe for straight turning.	
16. Rough turn section A and section B.	
17. Finish turn section A and section B as per drawing.	
18. Turn work end for end and hold section D $\frac{3}{4}$" collet with $1\frac{3}{4}$" projecting. True up with center if necessary.	
19. Mount drill chuck in the tailstock with $\frac{5}{16}$" drill.	
20. Deep-hole drill to depth as per drawing. Use lubricant and prevent chip buildup by frequently withdrawing drill.	20. Call attention to the need for lubricant and frequent drill withdrawal to prevent chip buildup.
21. Finish drill 4" deep with $\frac{33}{64}$" drill.	
22. Set tool for chamfering 60° x $\frac{1}{16}$ depth and chamfer.	22. Demonstrate use of the compound set at 30° with tool bit to get a countersunk hole.
23. Start $\frac{9}{16}$"-18 tap square for two turns supporting with center.	
24. Finish tap by hand.	
25. Deburr and polish.	
26. Hand in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project II *Project Name:* Ball peen hammer

Job No. 2 *Job name:* Cap *D.O.T. No.* 604.280

Drawing Nos. 5.6 *Time:* 4 hrs.

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Turning
4. Chamfering
5. Knurling
6. Filing
7. Polishing
8. Cutting off
9. Threading
10. Recessing-undercutting

Equipment:

Engine lathe
3-jaw chuck
Drill chuck
Tool bits
Center drill
Knurling tool
Collet assembly
Lathe file
Emery cloth

Materials

24ST aluminum, $\frac{3}{4}$" dia. x $3\frac{1}{2}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Place stock in 3-jaw universal chuck with stock projecting $1\frac{1}{2}$".	
2. Arrange for proper spindle speed.	2. Elaborate on use of formula for proper r.p.m.
3. Set lathe for facing and face end.	
4. Center drill from tailstock spindle.	4. Demonstrate drill chuck uses.
5. Set lathe for turning.	5. Support with tailstock center.
6. Turn knurled diameter to .740".	
7. Rough turn threaded diameter plus $\frac{1}{32}$".	
8. Set up and fine knurl as per drawing.	
9. Set lathe for turning and finish turn $\frac{9}{16}$" diameter to .560" and shoulder to $\frac{3}{8}$".	
10. Set tool for recessing.	
11. Cut recess for threading.	
12. Set tool for chamfering.	
13. Chamfer 45° x $\frac{1}{16}$".	
14. Arrange gearing for cutting thread as per drawing.	
15. Set tool for thread cutting.	15. Set compound to the right 30° to cut right-hand thread. Compound infeed is $\frac{.75}{\text{No. of threads}}$.

16. Cut $\frac{9}{16}$"-18 thread to fit tapped hole of part 2.
17. Withdraw tailstock.
18. Set cutoff tool and cut off work $\frac{1}{32}$" plus length indicated on drawing.
19. Mount collet assembly with $\frac{3}{4}$" collet.
20. Screw cap into handle Part 2. Place handle in lathe collet with cap end projecting $\frac{1}{2}$".
21. Set lathe tool for facing and face end of cap to length as per drawing.
22. Round end of cap (form tool or file).
23. File lightly to remove tool marks, then polish.
24. Hand in for inspection and grade.

Unit No. *Operator's job title:* Engine lathe operator

Project II *Project Name:* Ball peen hammer

*Job No.*3 *Job name:* Head *D.O.T. No.*604.280

Drawing Nos. 5,6 *Time:* 6 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Straight turning
3. Filing
4. Polishing
5. Measuring
6. Laying out
7. Forming
8. Center drilling
9. Cut off

Equipment:

Engine lathe
4-jaw independent chuck
Tool bits
Center drill
Drill chuck
Center rest

Materials

CRS SAE 1018, 1" dia. x $6\frac{1}{2}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Place stock in 4-jaw independent chuck with $4\frac{1}{2}$" projecting. Adjust jaws so that stock runs true.	1. Demonstrate use of concentric rings for approximate setting and use of indicator for more accurate one.
2. Face end.	
3. Center drill end of stock.	
4. Adjust tailstock to support end of work.	4. The ball end of this part is to be formed on end supported by tailstock. Allow $\frac{5}{16}$" stock on ball end for removing the center when the ball is formed.
5. Set right-hand turning tool with left-hand toolholder for turning.	5. See Figure 10-88, Machining Fundamentals by Walker.
6. Rough turn $\frac{7}{8}$" dia. plus $\frac{1}{32}$".	
7. Rough turn $\frac{3}{4}$" dia. plus $\frac{1}{32}$".	
8. Finish turn $\frac{7}{8}$" and $\frac{3}{4}$" diameters. File lightly and polish with emery cloth.	
9. Layout and mark location of the concave grooves as per drawing.	
10. Rough turn both grooves using a $\frac{3}{16}$". round nose turning tool.	

PROCEDURE	TECHNIQUES AND RELATED INFO.
11. Finish turn both grooves as per drawing. Polish grooves with emery cloth.	
12. Place center rest in position with jaws in line with $\frac{7}{8}$" diameter section of work and clamp center rest to lathe bed.	
13. Adjust center rest jaws to center up on $\frac{7}{8}$" dia. section and withdraw tailstock. Put oil on work to lubricate jaws.	13. Bring jaws up lightly to $\frac{7}{8}$" dia. so that concentricity remains true.
14. Set lathe tool for facing and face to length as per drawing. This operation should remove the center hole from the end of work.	
15. Set concave forming tool for turning ball.	
16. Rough turn ball end and finish turn.	
17. File ball lightly and polish with emery cloth.	
18. Remove center rest from lathe.	
19. Set cutoff tool and cut off work $\frac{1}{32}$" plus length indicated on drawing.	
20. Place work in lathe chuck. Use soft metal around work to prevent marring of surface by chuck jaws. Grip on center section, allowing large end to project 1" and true as before.	
21. Set lathe tool for facing and face to length as per drawing.	
22. Round face as per drawing.	22. Illustrate use of form tool or file for rounding.
23. File face lightly to remove tool marks. Polish with emery cloth.	
24. Hand in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project II *Project Name:* Ball peen hammer

Job No. 4 *Job name:* Pin *D.O.T. No.* 604.280

Drawing Nos. 5,6 *Time:* $\frac{1}{2}$ hour

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Filing
3. Polishing
4. Measuring

Equipment:
Engine lathe
Collet attachment and $\frac{1}{8}$" collet
Tool bits
Lathe file
Polishing cloth
6" scale

Materials
CRS SAE 1018, $\frac{1}{8}$" dia. x 1" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount collet assembly and tighten workpiece in $\frac{1}{8}$" collet.	
2. Face one end to clean up.	
3. Face opposite end to $\frac{7}{8}$" length.	
4. File both ends to $\frac{7}{16}$" radius.	4. Run at slightly higher speed than for turning.
5. Polish with emery cloth.	
6. Hand in for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project III *Project Name:* Die wrench

Job No. 1 *Job name:* Body *D.O.T. No.*604.280

Drawing No. 7 *Time:*5 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Drilling
4. Reaming
5. Boring
6. Filing

Equipment:

Engine lathe	Boring tool and holder
3-jaw chuck	Carriage stop
Drill chuck	6" rule
Center drill	Inside caliper
$\frac{47}{64}$" drill	Inside micrometer
$\frac{3}{4}$" machine reamer	Toolholder and tool bits

Materials
SAE 1018 CRS, $1\frac{3}{4}$" dia. x $\frac{3}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and remove sharp edges.	
2. Locate in 3-jaw chuck to face end and file radius.	2. Demonstrate use of single-cut file. Stress safety when filing work close to chuck jaws.
3. Reverse piece and true up faced side in 3-jaw chuck.	3. Use parallel to true up faced side with chuck face. Caution: Be sure to remove parallel before starting machine!
4. Face to length and file radius.	
5. Center drill.	
5A. Drill through with $\frac{5}{16}$" drill.	
6. Drill through with $\frac{47}{64}$" drill.	6. Use reamer to check hole for oversize condition before drilling all the way through. Point out proper speed and feed for drilling. $\frac{CSX4}{D}$ = 544 r.p.m. Use light feed.
7. Ream with $\frac{3}{4}$" machine reamer.	7. Introduce slower speeds for reaming and use of cutting oil.

PROCEDURE	TECHNIQUES AND RELATED INFO.
8. Set up boring tool and carriage stop.	8. Demonstrate depth setting with carriage stop using $\frac{1}{8}$" block between carriage and stop.
9. Bore to size and depth.	9. Explain boring principles and set up. Stress this point: Do not power feed against carriage stop. Introduce the use of inside calipers for checking diameter of bore. Make final size check with inside micrometer.
10. Break sharp edges and submit for inspection and grade.	10. Show how to break sharp edges with emery cloth.

Unit No. *Operator's job title:* Engine lathe operator

Project III *Project Name:* Die Wrench

Job No. 2 *Job name:* Handle *D.O.T. No.* 604.280

Drawing No. 7 *Time:* 7 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Knurling
4. Straight turning
5. Taper turning
6. Undercutting
7. Threading
8. Radius forming

Equipment:
Engine lathe
Collet attachment
$\frac{3}{8}$" and $\frac{1}{2}$" collets
Lathe centers
Drive plate
Lathe dog
Toolholder and tool bits
Threading tool
Center gage
Outside calipers and 6" rule
1" micrometer
$\frac{1}{4}$"-28 thread gage

Materials
SAE 1018 CRS,
2 pieces $\frac{1}{2}$" dia. x $3\frac{7}{8}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and remove sharp edges.	
2. Set up collet attachment and locate work in $\frac{1}{2}$" collet.	2. Demonstrate correct procedure for mounting collet attachment and using collets. Stress clean spindle and correct key alinement.
3. Face and center drill one end of both pieces.	3. Explain the value of doing each operation on both pieces before doing the next operation.
4. Reverse in collet and face and center drill.	4. Point out the need to remove the center on radius end later, thus controlling the hole depth.
5. Attach lathe dog and locate between centers.	5. Review technique of center mounting and checking to eliminate taper.
6. Knurl required length.	6. Allow for center removal on radius end when measuring length of knurled portion.
7. Straight turn $\frac{3}{8}$" dia. to length.	
8. Set compound to $1\frac{1}{2}°$ angle with center line and turn taper.	8. Introduce hand feed turning with radius tool. Use calipers to check small diameter of taper.

PROCEDURE	TECHNIQUES AND RELATED INFO.
9. Straight turn thread diameter.	9. Stress the plus .000" tolerance on O.D. of thread.
10. Make undercut at shoulder.	10. Use tool bit ground to $\frac{1}{16}$" width to plunge cut to depth. Check diameter with calipers.
11. Cut thread to fit gage.	11. Review threading setup with compound at 30°. Use a narrow point threading tool to thread to $\frac{1}{16}$" undercut. Tool must be at center height. Compound infeed is $\frac{.75}{\text{No. of threads}}$.
12. Locate in collet on $\frac{1}{2}$" diameter and face off center on large end.	12. Stress use of appropriate size collet to hold $\frac{1}{2}$" knurled diameter of oversize.
13. Form radius on end.	13. Use radius tool or file.
14. Remove all sharp edges and polish.	
15. Submit for inspection and grade.	

Unit No. | *Operator's job title:* Engine lathe operator

Project IV | *Project Name:* Fly tool face cutter

Job No. 1 | *Job name:* Body | *D.O.T. No.* 604.280

Drawing No. 8 | *Time:* $3\frac{1}{2}$ hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Truing
2. Facing
3. Chamfering
4. Shoulder turning

Equipment:
Engine lathe
4-jaw independent chuck
Micrometer carriage stop
Right-hand toolholder
Rough turning tool
$\frac{1}{8}$" radius turning tool
Chalk
Dial indicator
1" micrometer
6" rule

Materials
1 pc. CRS S.A.E. 1018.
2" dia. x $2\frac{7}{8}$" long

Selected references:
Machine Tool Technology by McCarthy and Smith, and Machining Fundamentals by Walker

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Cut stock to length as per drawing, using a power saw.	1. Cut stock $\frac{3}{16}$" to $\frac{1}{8}$" longer than finished length.
2. Remove all burrs with a file.	
3. Mount a 4-jaw independent chuck on lathe spindle.	3. Caution: Use a cradle to eliminate damage to lathe ways and the need for holding a heavy chuck.
4. Clamp 2" dia. stock in 4-jaw chuck. Leave $1\frac{11}{16}$" extending from chuck jaw faces.	4. Use the concentric rings to set jaws for 2" dia. stock.
5. True up work to a total indicator runout of .001".	5. Explain the meaning of total indicator runout (T.I.R.).
6. Face to clean up saw marks.	6. Caution: Do not remove more material than necessary to achieve a smooth surface.
7. Set up a turning tool and rough turn to $\frac{11}{16}$" dia. by $1\frac{3}{8}$" long.	7. Set rough turning tool slightly above center and away from direction of feed. Select the proper roughing speed and feed.

PROCEDURE	TECHNIQUES AND RELATED INFO.
8. Set up finish turning tool with $\frac{1}{8}$" radius on nose of leading edge.	8. Use a micrometer carriage stop and set for required length as indicated on drawing.
9. Turn to .623" dia. and face shoulder to $1\frac{1}{2}$" length.	9. Check micrometer calipers for accuracy using a sizing standard.
10. Turn chamfers $\frac{1}{16}$" x 45° on end of shank and on body.	10. Use compound set to proper angle.
11. Check all sizes for correct dimensions before removing from chuck.	
12. Place finished diameter in a $\frac{5}{8}$" collet and skim cut 2" dia. to run true.	
13. Remove all sharp edges with a file and emery cloth.	
14. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project V *Project Name:* Self-centering vise

Job No. 1 *Job name:* Jaw-actuating screw *D.O.T. No.* 604.280

Drawing Nos. 9,10 *Time:* 7 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Turning
4. Recessing
5. Chamfering
6. Layout
7. Measuring
8. Threading

Equipment:
Engine lathe
Collet attachment
Tool bits
Center drill
Drill chuck
Lathe centers
Hermaphrodite calipers

Materials
CRS 1020, $\frac{1}{2}$" dia. x $4\frac{7}{8}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount collet chuck assembly with $\frac{1}{2}$" collet.	
2. Arrange for proper spindle speed.	
3. Set lathe tool for facing.	
4. Face both ends to length as per drawing.	
5. Drill $\frac{3}{16}$" dia. hole (with No. 2 center drill) in both ends, using drill chuck in tailstock spindle.	
6. Remove drill chuck and replace tailstock center.	
7. Arrange headstock for turning between centers.	
8. Place shaft between centers in lathe. Drive with lathe dog.	8. Discuss common error of binding lathe dog.
9. Layout shoulder dimensions.	
10. Set lathe tool for turning.	
11. Rough turn $\frac{3}{8}$" diameter. Finish turn to .375".	
12. Set tool for recessing $\frac{1}{4}$" slot.	
13. Recess to $\frac{3}{8}$" diameter by $\frac{1}{4}$" width.	
14. Set chamfering tool.	
15. Chamfer $\frac{1}{16}$" x 45° all edges as per drawing.	
16. Turn piece end for end. Drive with lathe dog and protect $\frac{3}{8}$" dia. with soft material.	

PROCEDURE	TECHNIQUES AND RELATED INFO.
17. Arrange gearing for cutting as per drawing.	
18. Set tool for thread cutting.	18. Set compound at 29½° or 30° to the right to cut right-hand thread.
19. Cut right-hand thread. Fit to mating part.	
20. Cut left-hand thread. Fit to mating part.	20. Set compound 29½° or 30° to the left to cut left-hand threads.
21. Remove all burrs and polish.	
22. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project V *Project Name:* Self-centering vise

*Job No.*2 *Job name:* Guide rod *D.O.T. No.*604.280

Drawing Nos. 9.11 *Time:* 1 hour

Objectives
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Chamfering
3. Measuring

Equipment:
Engine lathe
Collet chuck attachment
Tool bits
Vernier calipers

Materials
CRS 1020, $\frac{1}{2}$" dia. x $4\frac{1}{8}$"

Selected references
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith.

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount collet chuck attachment with $\frac{1}{2}$" collet. Tighten with draw bar and have stock projecting $\frac{1}{2}$".	
2. Set lathe tool for facing and chamfering.	
3. Face one end. (Duplicate operations for both rods.)	3. Set lathe compound parallel to ways, lock carriage, and use dial for depth settings.
4. Chamfer end $\frac{1}{16}$" x 45°.	
5. Turn piece end for end and take light facing cut.	
6. Remove stock and measure overall length.	
7. Finish facing to length as per drawing.	7. Bring tool bit up to work face and remove the required material by using the compound dial.
8. Chamfer end $\frac{1}{16}$" x 45°.	
9. Remove burrs and polish.	
10. Submit for inspection and grade.	

44

Unit No. *Operator's job title:* Engine lathe operator

Project V *Project Name:* Self-centering vise

Job No. 3 *Job name:* Knurled handle *D.O.T. No.* 604.280

Drawing Nos. 9,12 *Time:* 3 hours

Objectives:

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Turning
4. Knurling
5. Drilling
6. Removing
7. Boring
8. Filing
9. Polishing
10. Layout
11. Measuring

Equipment:

Engine lathe
3-jaw universal chuck
Tool bits
Drill chuck
Center drill
Knurling tool
$\frac{3}{16}$" and $\frac{11}{32}$" drills
Boring tool
$\frac{3}{8}$" machine reamer
$\frac{3}{8}$" hardened mandrel
Lathe file
Micrometer
Hermaphrodite calipers

Materials

Aluminum 24 ST, $1\frac{1}{2}$" dia. by 2" long

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Place stock in 3-jaw universal chuck with $1\frac{3}{8}$" projecting.	1. Remove burrs from workpiece and adjust so stock runs true.
2. Set lathe tool for facing and face end.	2. See content outline, Item VII, Speeds and Feeds.
3. Center drill end of stock with center drill held in drill chuck in tailstock spindle.	
4. Remove drill chuck and replace with tailstock center.	
5. Adjust tailstock to support end of work.	
6. Set lathe tool for turning.	
7. Take light cut on $1\frac{1}{4}$" diameter so that stock is clean and runs true for 1" length.	
8. Set medium knurl and knurl machined surface.	8. Adjust the lathe to a slow back geared speed and a fairly rapid feed. Force the knurls slowly into the work surface until a pattern begins to develop, then feed toward headstock and flood with cutting fluid.
9. Remove the tailstock center and replace with drill chuck.	

PROCEDURE	TECHNIQUES AND RELATED INFO.
10. Drill through hole with $\frac{3}{16}$" drill.	10. Back drill out frequently to remove chips from flutes.
11. Redrill with $\frac{11}{32}$" drill.	
12. Set boring tool and bore to .365".	12. This operation trues hole and pilots reamer straight.
13. Use $\frac{3}{8}$" machine reamer and ream to size.	13. Locate reamer in the bored hole before tightening in the drill chuck. Use a cutting speed about that for a similar size drill, and a slow steady feed with a cutting fluid.
14. Remove workpiece and press $\frac{3}{8}$" dia. hardened mandrel through reamed hole.	14. Enter small end of mandrel in hole and position so that larger diameter of the mandrel is at the knurled end. Use oil in hole before pressing in arbor press.
15. Arrange lathe for turning between centers. Clamp lathe dog on the larger diameter mandrel end and mount between centers.	
16. Layout shoulder lengths as per drawing.	
17. Set lathe tool for turning and facing.	
18. Rough turn $\frac{3}{4}$" diameter and shoulder dimensions plus $\frac{1}{32}$".	
19. Finish turn $\frac{3}{4}$" diameter.	
20. Face $\frac{5}{8}$" shoulder as per drawing.	
21. Face $\frac{3}{4}$" shoulder as per drawing.	
22. Round all sharp edges with lathe file.	
23. Polish with emery cloth.	
24. Press out hardened mandrel.	24. Support on knurled end and press small end of mandrel through the work-piece on the arbor press.
25. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VI *Project Name:* Close quarters hacksaw

Job No. 1 *Job name:* Frame *D.O.T. No.*604.280

Drawing Nos. 13, 14 *Time:* 1 hour

Objectives
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Threading with die
3. Radius forming

Equipment:

Engine lathe	Die and die stock
3-jaw chuck	Cutting oil
Toolholder	12" rule
Tool bits	Single-cut mill file

Materials
SAE 1018 CRS,
1 pc. $\frac{5}{16}$" dia. x $11\frac{3}{8}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and remove sharp edges.	
2. Mount in 3-jaw chuck and face end.	2. Select a 3-jaw chuck for more holding power during the die threading operation.
3. Form radius with radius tool.	3. Use file or forming tool.
4. Reverse, face to length, and chamfer.	
5. Locate die, support with tailstock, and revolve machine by hand to cut thread.	5. Follow the die with the tailstock to keep it straight. Support die stock handle with toolholder shank. Use cutting oil whenever threading steel.
6. Remove burrs and polish.	
7. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VI *Project Name:* Close quarters hacksaw

*Job No.*2 *Job name:* Handle *D.O.T. No.*604.280

Drawing Nos. 13,14 *Time:* 6 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Straight turning
4. Angle turning
5. Knurling
6. Drilling
7. Tapping

Equipment:
Engine lathe
Collet attachment
Lathe centers
Drive plate
Lathe dog
Knurling tool
Toolholder and tool bits
Drill chuck
Center drill
No. 6 and $\frac{11}{16}$" drills
$\frac{1}{4}$"-20 tap and handle

Materials
Aluminum 24 ST, 1" dia. x 5" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and remove sharp edges.	
2. Set up collet attachment and 1" collet.	
3. Locate work in collet, face, and center drill.	3. Stress cutting speeds for aluminum and use kerosene for cutting fluid. Aluminum is machined over 300 ft. per minute.
4. Reverse piece, face to length, and center drill.	
5. Locate between centers with dog and drive plate.	5. Locate dog close to end to clear knurling tool.
6. Turn to .927" ± .002", $4\frac{1}{4}$" long.	6. Turn .010" undersize before knurling.
7. Turn to .875 ± .002", $\frac{3}{16}$" long.	
8. Knurl with medium pitch knurl.	8. Bring size up to .937 ± .002 for fit in collet.
9. Remove dog and lathe centers and remount collet attachment.	
10. Locate in collet and turn end to .875" ± .002", $\frac{7}{8}$" long.	10. Point out need to be careful not to mar work with collet. Avoid heavy cuts when holding in a collet.
11. Turn .500" ± .002, $\frac{5}{16}$" long.	
12. Set compound to 30° off centerline and cut angle to blend with $\frac{1}{2}$" dia.	12. Caution: do not run into .500" dia. when machining the 30° angle.

PROCEDURE	TECHNIQUES AND RELATED INFO.
13. Mount drill chuck and No. 6 drill in tailstock and drill hole $1\frac{1}{2}$" deep.	
14. Start $\frac{1}{4}$"-20 tap in drilled hole, guiding it with tailstock center; tap $\frac{1}{2}$" deep.	14. Guide the tap with tailstock center to assure straight threads.
15. Remove tap, reverse work in collet and drill $\frac{5}{16}$" dia., $3\frac{3}{4}$" deep.	15. Use pilot drill to depth before using large drill. Use kerosene for lubricant on aluminum.
16. Remove drill chuck, locate $\frac{11}{16}$" drill in tailstock spindle and drill $3\frac{3}{4}$" deep.	
17. Remove work and finish tapping $\frac{1}{4}$"-20 thread at the bench.	
18. Remove burrs and polish.	
19. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VI *Project Name:* Close quarters hacksaw

*Job No.*3 *Job name:* Adjustable blade retainer *D.O.T. No.*604.280

Drawing Nos. 13,14 *Time:* 2 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Turning
3. Layout
4. Measuring
5. Chamfering
6. Threading
7. Filing
8. Polishing
9. Cutting off

Equipment:

Engine lathe
3-jaw chuck
Toolholder
Tool bits
Die and die stock
Cutting oil
Tail stock center
Jacobs chuck
Center drill
Lathe file
Emery cloth

Materials

CRS 1020, $\frac{1}{2}$" dia. x $3\frac{3}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount 3-jaw chuck on the spindle.	1. Stress that mating spindle and inside of chuck must be free of burrs and chips when mounting.
2. Select $\frac{1}{2}$" dia. x $3\frac{3}{4}$" long stock and remove sharp edges.	
3. Tighten 3-jaw chuck with $1\frac{7}{8}$" projecting.	3. Caution: After tightening workpiece, remove the chuck wrench immediately.
4. Take facing cut.	
5. Mount Jacobs chuck and center drill in tailstock. Center drill.	5. Demonstrate that the tailstock and headstock must be in alignment for this operation.
6. Layout $1\frac{1}{2}$" shoulder length plus $\frac{1}{4}$" with hermaphrodite.	6. The $\frac{1}{4}$" excess will be removed after turning.
7. Rough turn .250" diameter while supporting end with tailstock center.	7. Do not cut shoulder distance beyond layout line.
8. Finish turn .250'diameter and face shoulder to layout.	
9. Face off end to $1\frac{1}{2}$" shoulder distance.	9. Discuss reason for supporting long slender work this way.
10. Chamfer end $\frac{1}{16}$" x 45°.	10. Point out that a chamfer prevents a knife edge on the thread and is a lead for the die.

PROCEDURE	TECHNIQUES AND RELATED INFO.
11. Locate die on work and backup with tailstock.	
12. Turn spindle by hand, follow with tailstock, and cut thread to $\frac{7}{8}$" length.	12. Use cutting oil.
13. Turn piece around and cut off to overall length.	13. Show importance of side clearance for a cutoff operation.
14. File sharp corners, then polish.	
15. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VI *Project Name:* Close quarters hacksaw

Job No. 4 *Job name:* Pin *D.C.T. No.* 604.280

Drawing Nos. 13,14 *Time:* $\frac{1}{2}$ hour

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Filing
3. Polishing
4. Measuring

Equipment:
Engine lathe
Collet assembly and $\frac{1}{8}$" collet
Tool bits
Emery cloth

Materials
$\frac{1}{8}$" drill rod, $\frac{5}{8}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Mount collet assembly and tighten workpiece in a $\frac{1}{8}$" collet.	
2. Face one end to clean up.	
3. Face opposite end to $\frac{1}{2}$" length.	
4. Polish ends with emery cloth.	
5. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

*Job No.*1 *Job name:* Nut *D.O.T. No.*604.280

Drawing Nos. 15, 16 *Time:* 3 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Drilling
4. Tapping
5. Measuring
6. Filing
7. Polishing

Equipment:
Lathe
3-jaw chuck
Center drill, Jacobs chuck
$\frac{1}{8}$", $\frac{1}{2}$", and $\frac{17}{32}$" drills
$\frac{5}{8}$"-11 tap
Lathe file
Emery cloth
1" micrometer
6" scale
Toolholder and tool bits

Materials
CRS $1\frac{1}{2}$" dia. x 1" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount in 3-jaw chuck and tighten.	
3. Face end to clean up surface.	
4. Reverse workpiece on parallel and tighten. (Caution: Remove parallel.)	
5. Face end to $\frac{7}{8}$" length.	
6. Center drill.	
7. Drill through with $\frac{1}{4}$" pilot drill in tailstock.	
8. Drill through with $\frac{1}{2}$" drill.	
9. Drill through with $\frac{17}{32}$" drill.	9. Demonstrate how to use drill as a reamer to maintain size.
10. Set up $\frac{5}{8}$"-11 tap to be guided square with tailstock.	10. Use cutting oil and slow speed.
11. Tap through; reverse spindle intermittently to break chip.	11a. Show how to use the unclamped tailstock, with the tap held in a drill chuck and the entire assembly guided by hand pressure. 11b. Other operations will be done on threaded stud of the vise jaw.

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

Job No. 2 *Job name:* Washer *D.O.T. No.* 604.280

Drawing Nos. 15, 16 *Time:* 2 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Turning
3. Chamfering
4. Center drilling
5. Drilling
6. Cutoff
7. Polishing

Equipment:
Lathe
3-jaw chuck
Toolholder and tool bits
Center drill and Jacobs chuck
$\frac{1}{4}$", $\frac{9}{16}$", and $\frac{41}{64}$" drills
1" micrometer
6" scale
Lathe file
Emery cloth

Materials
CRS $1\frac{1}{2}$" dia. x $1\frac{3}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Extend stock 1" from face of 3-jaw chuck and tighten.	
3. Take facing cut to clean up surface.	
4. Turn O.D. to clean up surface to $\frac{15}{16}$" length.	
5. Chamfer 45° x $\frac{1}{16}$".	
6. Center drill.	
7. Drill 1" deep with $\frac{1}{4}$" pilot drill.	
8. Drill 1" deep with $\frac{9}{16}$" drill.	
9. Drill 1" deep with $\frac{41}{64}$" drill.	
10. Cut off to $\frac{3}{16}$" width.	10. Use cutoff tool $\frac{1}{8}$" to $\frac{3}{16}$" wide.
11. Face remaining piece to clean up.	
12. Chamfer 45° x $\frac{1}{16}$".	
13. Cut off to $\frac{3}{16}$" width.	
14. Polish and deburr.	
15. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

Job No. 3 *Job name:* Handle *D.O.T. No.* 604.280

Drawing Nos. 15, 16 *Time:* 4 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Turning
3. Knurling
4. Cutting off
5. Center drilling
6. Chamfering
7. Filing

Equipment:
Lathe
3-jaw chuck
Center drill and Jacobs chuck
Toolholder and tool bits
Fine knurling tool
Countersink
1" micrometer
6" scale
Lathe file
Emery cloth

Materials
CRS $\frac{1}{2}$" dia. x 6" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Tighten in 3-jaw chuck and face end.	
3. Center drill.	
4. Extend 5" from chuck face, support with tailstock center, and tighten work.	
5. Rough turn $\frac{1}{4}$" dia. to $\frac{9}{32}$" and face shoulder to $3\frac{5}{16}$".	
6. Finish turn $\frac{1}{4}$" dia. and face shoulder to $3\frac{5}{16}$".	
7. Mount fine knurl and knurl to within $\frac{1}{8}$" of chuck face.	
8. Cut off to $3\frac{15}{16}$" length. (Part A)	
9. Face off remainder to clean up. (Part B)	
10. Center drill.	
11. Drill $\frac{11}{16}$" depth with $\frac{7}{32}$" drill. Countersink to $\frac{5}{16}$" dia.	
12. Cut off to $\frac{5}{8}$" length.	
13. Mount collet assembly with $\frac{1}{2}$" collet.	
14. Chamfer both ends (Part B) to 45° x $\frac{1}{16}$".	
15. Tighten Part A in $\frac{1}{4}$" collet.	
16. Chamfer both ends 45° x $\frac{1}{16}$".	
17. Finish turn $\frac{7}{32}$" dia. x $1\frac{11}{16}$" length.	17. Fit to Part B.
18. Deburr and polish.	
19. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

*Job No.*4 *Job name:* Guide pin *D.O.T. No.*604.280

Drawing Nos. 15, 16 *Time:* 1 hour

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Chamfering
3. Measuring
4. Filing
5. Polishing

Equipment:
Lathe
Collet assembly and $\frac{1}{2}$" collet
Toolholder and tool bits
Lathe file
Emery cloth
6" scale

Materials
Drill rod
$\frac{1}{2}$" dia, x $3\frac{5}{8}$" long (2 required)

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE *TECHNIQUES AND RELATED INFO.*

1. Select stock and deburr.
2. Mount collet assembly with $\frac{1}{2}$" collet.
3. Tighten workpiece and face one end.
4. Reverse and face to $3\frac{1}{2}$" length.
5. Chamfer 45° x $\frac{1}{16}$".
6. Deburr and polish.
7. Submit for inspection and grade.

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

Job No. 5 *Job name:* Fixed and movable jaws *D.O.T. No.*604.280

Drawing Nos. 15, 17 *Time:* 4 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Measuring
3. Turning
4. Undercutting
5. Threading
6. Knurling
7. Forming
8. Polishing

Equipment:

Lathe
4-jaw chuck
Height gage
Layout plate
Center punch
Center drill
Indicator
Toolholder and tool bits
Knurling tool
Lathe file
Emery cloth

Materials

CRS $1\frac{1}{4}$" x $1\frac{1}{2}$" x $7\frac{3}{16}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 4-jaw chuck and tighten workpiece.	2. Show how concentric rings on chuck are used to center workpiece.
3. Face one end to clean up.	
4. Reverse workpiece and face overall length to 7".	
5. Layout center at $\frac{5}{8}$"-11 thread on ends and center panel.	5. Demonstrate use of height gage on layout plate.
6. Center drill.	6. Use shop practice to select alternatives for center drilling.
7. Mount workpiece in 4-jaw chuck and tighten jaws until hole runs true. Leave 3" extending from chuck face.	7. Use tailstock center to get approximate center and then indicate center drilled hole concentric with spindle.
8. Rough turn $\frac{21}{32}$" dia. and face shoulder to $2\frac{3}{4}$ length.	
9. Undercut $\frac{1}{8}$" width x $\frac{17}{32}$" dia.	
10. Finish turn to .625" dia. and face shoulder to $2\frac{3}{4}$" length.	
10A. Chamfer 45° x $\frac{1}{16}$".	
11. Set for threading $\frac{5}{8}$"-11 thread.	
12. Thread to $1\frac{3}{4}$" length.	12. Fit to mating nut.
13. Mount nut tight on screw.	

PROCEDURE	TECHNIQUES AND RELATED INFO.

14. Take skim cut to clean up $1\frac{1}{2}$" dia. on nut.
15. Set up medium knurling tool and knurl O.D. of nut.
16. File $\frac{1}{8}$" radius on either end of nut.
17. Deburr and polish.
18. Submit for inspection and grade.

Unit No. *Operator's job title:* Engine lathe operator

Project VII *Project Name:* Bench vise

Job No. 6 *Job name:* Screw *D.O.T. No.* 604.280

Drawing Nos. 15, 16 *Time:* 6 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Turning
4. Undercutting
5. Threading
6. Forming
7. Polishing
8. Measuring

Equipment:
Lathe
3-jaw chuck
Toolholder and tool bit
Center drill
Jacobs chuck
Collet assembly and $\frac{1}{2}$" collet
Lathe file
Emery cloth
1" micrometer
6" scale
Tailstock center

Materials
CRS 1" dia. x $5\frac{5}{16}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten shaft.	
3. Face off end to clean up.	
4. Center drill.	
5. Extend work 4" from chuck face, support with tailstock center, and tighten.	
6. Finish turn $\frac{15}{16}$" dia. to $3\frac{7}{8}$" length.	
7. Rough turn $\frac{1}{2}$" dia. to $3\frac{1}{2}$" length.	
8. Finish turn .500" dia. and face shoulder to $3\frac{1}{2}$" length.	
9. Chamfer 45° x $\frac{1}{16}$".	
10. Undercut $\frac{1}{8}$" width x $\frac{27}{64}$" dia.	
11. Setup for threading.	11. Fit to standard nut.
12. Thread $\frac{1}{2}$"-13 UNC.	
13. Mount collet assembly with $\frac{1}{2}$" collet.	
14. Reverse workpiece and tighten.	
15. Face to overall length $5\frac{9}{16}$".	
16. Finish turn $\frac{9}{16}$" dia. x $\frac{9}{16}$" length.	16. Use form tool with $\frac{1}{8}$" R.
17. Finish $\frac{15}{32}$" R.	17. Use file or form tool.
18. Deburr and polish.	
19. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VIII *Project Name:* Lathe dieholder

Job No. 1 *Job name:* Sliding holder *D.O.T. No.* 604.280

Drawing No. 18 *Time:* 8 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Turning
4. Knurling
5. Undercutting
6. Forming
7. Drilling
8. Boring
9. Filing
10. Polishing
11. Layout
12. Measuring

Equipment:

Engine lathe
3-jaw chuck
Collet attachment, collets
Toolholder and tool bits
Headstock, tailstock centers
Micrometer stop
Jacobs chuck, center drill
Driving dog
1-2" micrometer
Vernier caliper
Knurling tool
Lathe file and emery cloth

Materials

CRS $2\frac{3}{8}$" dia. x $3\frac{1}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr ends.	
2. Mount 3-jaw chuck and tighten workpiece.	
3. Take facing cut to clean up rough surface.	
4. Center drill.	
5. Reverse workpiece and take facing out to $3\frac{1}{8}$" length.	
6. Center drill.	
7. Extend workpiece $2\frac{1}{2}$", support end in tailstock center, and tighten chuck.	7. Explain that seating center in the tailstock center before clamping chuck helps.
8. Rough turn 1.00" diameter plus $\frac{1}{16}$" and face shoulder to $2\frac{1}{8}$".	
9. Remove chuck and mount workpiece between centers with drive dog clamped to $1\frac{1}{16}$" diameter.	
10. Take a small finish cut to clean up $2\frac{3}{8}$" diameter.	
11. Mount coarse knurl and knurl $2\frac{3}{8}$" diameter.	11. Emphasize the use of oil and backgears.
12. Finish turn $\frac{1}{32}$" depth on either side of knurl to $\frac{3}{4}$" width.	
13. Finish $\frac{3}{16}$" radius on either end.	13. File or use a form tool.
14. Reverse workpiece and finish turn 1.00" diameter and face shoulder to $2\frac{1}{8}$" length.	14. Protect knurl with soft material.

PROCEDURE	TECHNIQUES AND RELATED INFO.
15. Undercut $\frac{31}{32}$" diameter x $\frac{1}{8}$" width.	
16. Finish $\frac{1}{8}$" radius.	16. Use file or form tool.
17. Mount collet assembly and hold shank in a 1" collet.	
18. Pilot drill with $\frac{1}{4}$" drill to $1\frac{3}{4}$" depth.	18. Use oil and back out drill frequently.
19. Finish drill $\frac{9}{16}$" diameter to $1\frac{3}{4}$" depth.	
20. Mount boring tool and micrometer stop, then rough bore 1.500" diameter to $1\frac{15}{32}$" diameter x .490" depth.	
21. Finish bore 1.500" diameter to fit die and face inside shoulder to $\frac{1}{2}$" depth.	21. Emphasize that mating parts are used for fitting.
22. Deburr and polish.	
23. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project VIII *Project Name:* Lathe dieholder

Job No. 2 *Job name:* Tapered shank support *D.O.T. No.* 604.280

Drawing No. 19 *Time:* 12 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Turning
3. Center drilling
4. Undercutting
5. Taper turning
6. Drilling
7. Boring
8. Measuring
9. Filing
10. Polishing

Equipment:

Engine lathe
3-jaw chuck
Toolholder and tool bits
Headstock and tailstock centers
Jacobs chuck, center drill
Driving dog
Micrometer 1" and 2"
Vernier caliper
No. 3 Morse taper adapter
Set of radius gages
$\frac{1}{4}$" and $\frac{7}{8}$" drills

Materials

CRS 2" dia. x $7\frac{1}{2}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr ends.	
2. Mount 3-jaw chuck and tighten workpiece.	
3. Take facing cut to clean up rough surface.	
4. Center drill.	
5. Reverse workpiece and face end to $7\frac{3}{8}$" length.	
6. Center drill.	
7. Rough turn tapered shank to 1" diameter and face shoulder to $4\frac{7}{8}$" length.	
8. Undercut $\frac{13}{16}$" diameter with radius tool to a length of $4\frac{7}{8}$".	8. Describe alternate methods for grinding single point form tools and checking them with a radius gage.
9. Finish turn .680" diameter to $\frac{5}{8}$" length.	
10. Finish $\frac{1}{8}$" radius on the end.	10. Use file or a form tool.
11. Set up taper attachment for given taper.	11. If attachment is not available, use offset tailstock method. Describe advantages of taper attachment.
12. Rough turn taper to .840" small end and .991" large end.	12. Demonstrate how to compensate for errors of taper until correct one is achieved.

PROCEDURE	TECHNIQUES AND RELATED INFO.
13. Finish turn taper leaving grinding stock .805" small end and .956" large end.	13. Show how to use micrometer, tapered adapter, or tapered gage for fitting.
14. Remove centers from lathe and mount tapered end of workpiece into headstock. Use adapter or bore-tapered nest if necessary.	14. Check for runout to make sure taper is seated correctly.
15. Finish turn 2" diameter to clean up surface.	
16. Pilot drill $\frac{1}{4}$" hole to 2" depth.	
17. Drill $\frac{7}{8}$" hole to 2" depth.	
18. Mount boring tool then rough bore $\frac{31}{32}$" diameter and 2" depth.	
19. Finish bore 1.002" ± .001" diameter to 2" depth.	19. Describe "go" and "no go" plug gages. Use mating part for a sliding fit.
20. Finish $\frac{1}{8}$" radii on 2" diameter.	20. Use file or form tool.
21. Deburr and polish.	
22. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project IX *Project Name:* Eccentric test shaft

Job No. 1 *Job name:* Shaft *D.O.T. No.* 604.280

Drawing No. 20 *Time:* 30 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Straight turning
3. Layout
4. Measuring
5. Chamfering
6. Threading
7. Taper turning
8. Eccentric turning
9. Grooving
10. Forming
11. Polishing

Equipment:
Engine lathe
3-jaw chuck
Toolholder
Center gage
Thread micrometer
Headstock and tailstock centers
Jacobs chuck, center drill
Lathe file
Emery cloth
Driving dog
V-block
Height gage

Materials
CRS 1020, 2" dia. x $6\frac{1}{4}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr ends.	
2. Mount 3-jaw chuck and tighten workpiece.	2. Discuss reasons for avoiding excessive overhang and runout.
3. Take facing out.	
4. Center drill to no greater than $\frac{1}{4}$" diameter. Caution: If this hole is any larger it would break into the eccentric center hole.	4. Point out that r.p.m. for this operation applies to the dia. of the center drill.
5. Reverse shaft in 3-jaw chuck.	
6. Take facing cut to overall length of $6\frac{1}{16}$"	
7. Center drill (no greater than $\frac{1}{4}$" dia.).	
8. Rough turn areas J and K to $1\frac{1}{8}$" diameter and face shoulder length to $\frac{1}{32}$" of blueprint dimension.	8. Support end with the tailstock center.
9. Tighten dog on $1\frac{1}{8}$" diameter and mount shaft between centers.	9. Demonstrate methods to check alignment and concentricity of centers.
10. Take a skim cut along entire length so that the O.D. is concentric with the centers.	10. Explain the importance of concentricity for all diameters.
11. Remove the dog, color both ends of the shaft with layout dye, and fasten in a V-block.	

PROCEDURE	TECHNIQUES AND RELATED INFO
12. Take the assembly to a layout plate and scribe a centerline on both ends with a height gage.	12. Discuss technique for scribing centerline by touching off from the top of the shaft with the gage and subtracting the radius.
13. Turn the centerline 90° and scribe a line on either end .250" up from the center.	
14. Center punch the intersection of these lines and center drill both sides. Caution: Do not break into true centers.	14. Explain the principle of eccentricity. Use the drill press or local shop practice to center drill eccentric centers.
15. Tighten dog on area K and mount between true centers.	
16. Rough turn areas A, B, and C to $1\frac{1}{16}$" dia. and face shoulder of section C to $\frac{1}{32}$" of blueprint length.	16. To maintain proper concentricity of several diameters rough turn all dimensions before finish turning to size.
17. Rough turn areas D and E to .250" dia. and face shoulder of section E to $\frac{1}{32}$" of blueprint length.	
18. Rough turn areas F, G, H, and I to $1\frac{15}{16}$" dia.	
19. Reverse workpiece, tighten dog on area A, place between eccentric centers and rough turn area H and I to $1\frac{3}{16}$" dia. Caution: Leave $\frac{1}{32}$" stock on either side of shoulders for areas H and I in order to finish face.	19. Use undercutting tool. Explain to student how this tool is used in between interfering diameters.
20. Place between true centers, rough turn area B to 1.560" dia., and face shoulder to $\frac{1}{32}$" of given dimension.	20. Use undercutting tool.
21. Finish turn areas J and K to 1.000" dia. and face shoulder of area J to given dimension.	
22. Finish turn area F to 1.888" dia.	22. Demonstrate the use of the formula O.D. = $\frac{\text{No. of teeth + 2}}{\text{diametral pitch}}$.
23. Remount between eccentric centers, finish turn areas H and I to 1.125" dia., and face to give shoulder dimensions.	23. Use undercutting tool.
24. Finish turn area H to .625" dia. and face to give shoulder dimension.	24. Use undercutting tool.
25. Remount between true centers, finish turn area G to 1.500" dia. and face to given shoulder dimension.	25. Use undercutting tool.

PROCEDURE	TECHNIQUES AND RELATED INFO.
26. Finish turn area J to .750" dia. and face to given shoulder dimension.	
27. Reverse workpiece, clamp dog to area K, and mount between centers.	27. Protect surface with soft material between set screw and workpiece.
28. Finish turn area A to .700" dia. and face shoulder to given dimension.	28. Review formula for minimum turned dia. when given the size of a hexagon across the slats.
29. Finish turn areas B and C to 1.000" dia. and face the shoulder of C to the given dimension.	
30. Finish turn areas D and E to 1.187" dia. and face shoulder of E to the given dimension.	
31. Finish turn area E to .875" dia. and face shoulders of E to the given dimensions.	31. Use undercutting tool.
32. Finish turn taper for area B by feeding along compound angle. Maintain .750" dia. x 1.125" length.	32. Review formula: angle of compound = tangent of angle = $\frac{.125}{1.125}$
33. Reverse workpiece, clamp dog to area A and mount between centers.	
34. Finish $\frac{1}{8}$" radii on area F.	34. Use form tool or file. Show the use of the radius gage.
35. Chamfer area K, $\frac{1}{8}$" x 45°.	
36. Set gearbox for 1"-8 UNC-LH and position threading tool and compound for left-hand threading.	36. Discuss important considerations for threading such as: compound angle, direction of feed, fitting and depth of cut.
37. Cut 1"-8 UNC-LH thread to size.	37. Fit to nut, thread micrometer, or 3-wire measurement.
38. Deburr and polish.	
39. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project X *Project Name:* Tap wrench

Job No. 1 *Job name:* Chuck body *D.O.T. No.* 604.280

Drawing No. 21 *Time:* 8 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Straight turning
4. Taper turning
5. Drilling
6. Boring
7. Cutting off
8. Tapping
9. Chamfering
10. Filing
11. Polishing

Equipment:

Lathe
Toolholder
Tool bits
Collet assembly and 1" collet
Jacobs chuck and center drill
Centers and driving dog
Medium knurling tool
$\frac{1}{4}$", $\frac{31}{64}$" drills
$\frac{3}{8}$"-16 tapping set
File
Emery cloth

Materials

CRS 1" dia. x $2\frac{1}{2}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet assembly with 1" collet.	
3. Tighten workpiece in collet and face one end to cleanup.	
4. Center drill.	
5. Reverse workpiece and face end to clean up.	
6. Center drill.	
7. Clamp driving dog to one end and mount assembly between centers.	
8. Finish turn to .980" dia. x 2" length.	
9. Mount medium knurl, then knurl .980" dia. to $1\frac{3}{4}$" length. (Do not raise knurl above 1" dia.).	9. Set lathe for low r.p.m.'s and use oil on knurl.
10. Mount collet assembly and tighten workpiece (1" collet).	
11. Set compound to given angle and turn $\frac{5}{8}$" dia. to $\frac{5}{8}$" length along given angle.	
12. Mount $\frac{1}{4}$" pilot drill in tailstock chuck and drill to $1\frac{3}{4}$" depth.	
13. Mount $\frac{31}{64}$" drill and drill to $1\frac{3}{4}$" depth.	
14. Set up for boring $\frac{1}{2}$" tapered hole, feeding with compound at given angle.	14. Show that side clearance is critical for small hole boring.

PROCEDURE	TECHNIQUES AND RELATED INFO.
15. Finish bore $\frac{1}{2}$" tapered hole to $\frac{7}{8}$" depth.	
16. Cut off to $1\frac{9}{16}$" length.	
17. Reverse workpiece and hold knurled dia. in a 1" collet.	17. Demonstrate that back face should not run out.
18. Face to overall length of $1\frac{1}{2}$".	
19. Bore to tap drill size for a $\frac{3}{8}$"-16 tap to $\frac{5}{8}$" depth.	
20. Set up for tapping the $\frac{3}{8}$"-16 hole and tap to depth.	20. Describe the use of the starting tap and the bottoming tap.
21. Chamfer end to $\frac{1}{8}$" depth.	
22. Deburr and polish.	
23. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project X *Project Name:* Tap wrench

Job No. 2 *Job name:* Wrench body *D.O.T. No.* 604.280

Drawing No. 21 *Time:* 10 hours

Objectives

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Drilling
4. Boring
5. Reaming
6. Form turning
7. Threading
8. Taper turning
9. Filing
10. Polishing

Equipment:

Lathe
Collet assembly and $\frac{3}{8}$" collet
Jacobs chuck and center drill
Toolholders and tool bits
$\frac{7}{32}$" drill, letter C drill
$\frac{1}{4}$" reamer
Centers and driving dog
Lathe file
Emery cloth

Materials

CRS $\frac{3}{4}$" dia. x $3\frac{3}{4}$" long

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet assembly with $\frac{3}{8}$" collet.	
3. Tighten workpiece in collet and take facing cut on end.	
4. Center drill to $\frac{1}{4}$" dia.	
5. Reverse workpiece and face end to $3\frac{5}{8}$". (Note: $\frac{1}{8}$" will be removed in later operation.)	
6. Center drill to $\frac{3}{8}$" dia.	
7. Mount $\frac{7}{32}$" dia. drill in tailstock and drill to $2\frac{1}{8}$" depth.	7. Point out that oil must be used and the drill retracted frequently.
8. Mount small boring tool to enter $\frac{7}{32}$" hole and bore to .240" dia., $\frac{1}{4}$" depth.	8. Demonstrate that the bored hole is concentric and used as a guide for the reamer.
9. Mount a "C" drill in the tailstock and drill to $2\frac{1}{8}$" depth.	
10. Mount a $\frac{1}{4}$" reamer and ream to $2\frac{1}{8}$" depth.	10. Emphasize that speeds for reamers are less than for drills.
11. Set up for turning between centers and clamp driving dog on end opposite reamed hole.	11. Protect surface with soft material.
12. Mount workpiece between centers and turn $\frac{5}{8}$" diameter to $1\frac{5}{8}$" length.	12. Describe the use of a form tool for turning shoulders with fillets.

PROCEUDRE	TECHNIQUES AND RELATED INFO
(Note: $\frac{1}{8}$" will be faced off end later to remove $\frac{3}{8}$" center.)	
13. Turn $\frac{5}{8}$" diameter to $\frac{3}{8}$" length and maintain $\frac{5}{8}$" length for threaded area.	
14. Set up for threading $\frac{3}{4}$"-16 dia. and finish to size.	14. Show how to use internal thread of chuck body as a threaded ring gage for fitting.
15. Remove from centers and tighten in a collet attachment with a $\frac{3}{4}$" collet.	15. Seat in a tailstock center before tightening to align for minimum runout.
16. Face off $\frac{1}{8}$" to remove center. Maintain $1\frac{1}{2}$" length.	
17. Set compound to given angle and finish turn nose to $\frac{3}{8}$" dia. by given included angle.	17. Point out that the carriage should be locked for this operation.
18. Reverse workpiece and form spherical end with file and emery cloth.	18. Describe the difference in speeds when filing and polishing.
19. Drill hole to intersect $\frac{1}{4}$" diameter. Use No. 20 drill.	
20. Tap hole 10-32-UNC-2B.	
21. Deburr and polish.	
22. Submit for inspection and grade.	

Unit No. | *Operator's job title:* Engine lathe operator

Project X | *Project Name:* Tap wrench

Job No. 3 | *Job name:* Handle | *D.O.T. No.* 604.280

Drawing No. 21 | *Time:* ½ hour

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Undercutting
3. Filing
4. Polishing
5. Measuring

Equipment:
Lathe
Collet attachment and $\frac{1}{4}$" collet
Toolholder
Tool bits
1" micrometer
Vernier caliper
Lathe file
Emery cloth

Materials
CRS $\frac{1}{4}$" dia. x $4\frac{1}{8}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarth, & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Set up collet assembly with $\frac{1}{4}$" collet.	
3. Tighten workpiece with draw bar and face both ends to 4" length.	
4. Undercut center $\frac{3}{8}$" wide by .220" dia.	. Demonstrate use of vernier caliper for measuring small undercuts.
5. File and polish ends.	
6. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project No. XI *Project Name:* Micrometer boring head

Job No. 1 *Job name:* Stop pin *D.O.T. No.*604.280

Drawing Nos. 22,23,24 *Time:* $\frac{1}{2}$ hour

Objectives:

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Turning
3. Chamfering
4. Measuring
5. Filing
6. Polishing

Equipment:

Engine lathe
Collet attachment and $\frac{3}{8}$" collet
Toolholder
Tool bits
1" micrometer
6" scale
Lathe file
Emery cloth

Materials

Drill rod $\frac{3}{8}$" dia. x $\frac{7}{8}$" long.

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet assembly and $\frac{3}{8}$" collet.	
3. Tighten workpiece and face end to clean up.	
4. Reverse workpiece and face to overall length $\frac{27}{32}$".	
5. Rough turn .250" dia. to $\frac{9}{32}$" and face shoulder to $\frac{1}{2}$".	5. Illustrate how the lathe compound set parallel to the ways can be used for depth settings. Note: Lock the carriage.
6. Finish turn .250" dia. to size and face shoulder to $\frac{1}{2}$" length.	
7. File $\frac{1}{16}$" x $\frac{1}{16}$" chamfer.	
8. Deburr and polish.	
9. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XI *Project Name:* Micrometer boring head

Job No. 2 *Job name:* Dial *D.O.T. No.*604.280

Drawing Nos. 22, 23 *Time:* 4 hours

Objectives

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Drilling
3. Turning
4. Chamfering
5. Threading
6. Undercutting
7. Cutting off
8. Filing
9. Polishing
10. Measuring

Equipment:

Lathe, 3-jaw chuck
Toolholder and tool bits
No. 21 drill
Jacobs chuck and center drill
1" micrometer
Vernier caliper
6" scale

Materials

CRS 1018, 1" dia. x 2" long

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr	
2. Mount 3-jaw chuck, extend stock $1\frac{1}{4}$" from chuck jaw face, and tighten.	
3. Take facing cut to clean up stock.	
4. Center drill.	
5. Drill No. 21 drill to $\frac{3}{4}$" depth.	
6. Rough turn $\frac{1}{2}$" dia. to .530" and face shoulder to $\frac{5}{8}$" length.	
7. Finish turn $\frac{.498}{.502}$ dia. to $\frac{5}{8}$" length.	
8. Chamfer end 45° x $\frac{1}{32}$".	
9. Mount cutoff tool and undercut $\frac{3}{4}$" length to $\frac{25}{32}$" x $\frac{1}{2}$" dia.	9. Undercut is for clearance to machine 45° angle on dia.
10. Undercut .250" width to $\frac{5}{16}$" dia.	
11. Turn compound to 45° and finish 45° angle to .990" dia.	
12. Deburr and polish.	
13. Set up for threading $\frac{1}{2}$"-20.	13. Use compound at 30° for threading.
14. Finish thread $\frac{1}{2}$"-20 UNF-2.	14. Fit thread to mating slide.
15. Deburr and polish.	
16. Cut off to $\frac{3}{4}$" length.	
17. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XI *Project Name:* Micrometer boring head

Job No. 3 *Job name:* Shank *D.O.T. No.* 604.280

Drawing Nos. 22, 23 *Time:* 4 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Drilling
3. Turning
4. Threading
5. Undercutting
6. Chamfering
7. Filing
8. Polishing
9. Measuring

Equipment:

Lathe
3-jaw chuck
Jacobs chuck and center drill
Toolholder and tool bits
Drive dog
Lathe file
Emery cloth
1" micrometer
6" scale
Vernier caliper

Materials

CRS SAE 1018, $\frac{3}{4}$" dia. x $2\frac{1}{4}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten workpiece.	
3. Face one end to clean up.	
4. Center drill end.	
5. Reverse workpiece and face to 2" overall length.	
6. Center drill end.	
7. Mount centers, drive plate, and tighten drive dog to one end of workpiece.	
8. Rough turn $.\frac{498}{502}$ dia. to $\frac{17}{32}$" and face shoulder to $1\frac{5}{16}$" length.	
9. Finish turn $.\frac{498}{502}$ diameter and face shoulder to $1\frac{5}{16}$" length.	
10. Reverse workpiece and tighten drive dog on end.	10. Protect surface beneath dog with soft material.
11. Take light cleanup cut on $\frac{3}{4}$" dia.	
12. Rough turn $\frac{1}{2}$"-20 thread to $\frac{17}{32}$" and face shoulder to $\frac{15}{32}$" length.	
13. Finish turn $\frac{1}{2}$"-20 thread to .500 and face shoulder to $\frac{15}{32}$" length.	
14. Undercut $\frac{1}{16}$" x $\frac{1}{32}$" deep.	
15. Chamfer $\frac{1}{16}$" x $\frac{1}{16}$".	
16. Set up for threading $\frac{1}{2}$"-20.	
17. Finish thread $\frac{1}{2}$"-20.	17. Fit to mating part.
18. Deburr and polish.	
19. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XI *Project Name:* Micrometer boring head

Job No. 4 *Job name:* Dovetail slide *D.O.T. No.* 604.280

Drawing No. 22 *Time:* 3 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing (4-jaw chuck)
2. Center drill
3. Drilling
4. Boring
5. Tapping
6. Measuring
7. Filing

Equipment:
Lathe
4-jaw chuck
Jacobs chuck
Center drill, $\frac{1}{4}$" drill, $\frac{7}{16}$" drill
Depth gage
Vernier calipers
10-32 and $\frac{1}{2}$"-20 tap
1-2" micrometer
Tap wrench

Materials
CRS SAE 1018, 1" x 1" x $1\frac{1}{2}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 4-jaw chuck and indicate work concentric with spindle.	2. Demonstrate that for greater accuracy indicating is done at the midpoints rather than the outer edge.
3. Face workpiece to clean up surface.	
4. Center drill.	
5. Drill with $\frac{1}{4}$" pilot drill 1" deep.	
6. Drill thru with No. 21 drill.	
7. Drill $\frac{7}{16}$" hole to $\frac{7}{8}$" depth.	
8. Mount boring tool and bore $\frac{29}{64}$" hole to $\frac{7}{8}$" depth.	8. Mention that boring corrects drilling runout.
9. Hand tap $\frac{1}{2}$"-20 UNF-2B square to axis using tailstock to feed.	
10. Retap with bottoming tap so that mating part threads flush.	
11. Reverse workpiece and face to $1\frac{3}{8}$" length.	
12. Hand tap 10-32 UNC-2B hole.	
13. Deburr and polish.	
14. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XII *Project Name:* Surface gage

Job No. 1 *Job name:* Adjustment screw *D.O.T. No.* 604.280

Drawing Nos. 25, 26 *Time:* 1 hour

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Knurling
2. Facing
3. Turning
4. Threading
5. Cutting off
6. Chamfering

Equipment:
Engine lathe
3-jaw chuck
Toolholder
Tool bits
10-32 die and diestock
Lathe file
1" micrometer
6" scale
Cutoff tool and holder

Materials
CRS $\frac{1}{2}$" dia. x 2" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck.	
3. Locate workpiece in chuck with $1\frac{1}{4}$" projecting from jaws.	3. Workpiece can be machined and cut off when held in this manner.
4. Face end to clean up.	
5. Rough turn to $\frac{13}{64}$" dia. x $\frac{3}{4}$" long.	
6. Finish turn .190" dia. x $\frac{3}{4}$" long.	
7. Chamfer end with file.	
8. Cut thread to shoulder with 10-32 die.	
9. Knurl area 1" from end.	9. Use hand feed to start die straight, guiding it with the tailstock, or use tailstock die holder.
10. Set up cutoff tool square to centerline and on center, cut off piece 1" long, and chamfer head.	10. Caution: Use cutting oil. Stop cutoff part way and file chamfer on head.
11. Deburr and polish.	
12. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XII *Project Name:* Surface gage

Job No. 2 *Job name:* Scriber point *D.O.T. No.* 604.280

Drawing Nos. 25, 26 *Time:* 1½ hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Turning
3. Threading
4. Taper turning
5. Chamfering
6. Filing
7. Polishing

Equipment:
Engine lathe
Collet holder and collet
Toolholder
Tool bits
10-32 UNF die
Die stock
Micrometer
6" scale
File

Materials
Drill rod $\frac{3}{8}$" dia. x $2\frac{5}{8}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet holder and $\frac{3}{8}$" collet.	
3. Tighten workpiece in collet and face end to clean up.	
4. Reverse in collet and face to length.	
5. Rough turn thread to $\frac{13}{64}$" dia. x $\frac{11}{16}$" long.	
6. Finish turn thread dia. to .190" x $\frac{11}{16}$" long.	
7. Cut thread with UNF 10-32 die.	7. Use hand rotation and guide die with tailstock. Use cutting oil.
8. Reverse piece in collet with $1\frac{3}{4}$" projecting.	
9. Set compound to 8° angle with centerline and turn point.	9. Take light cuts and fine feed to turn this length. Set turning tool exactly on centerline and take light cuts to prevent bending work.
10. File and polish to remove tool marks.	
11. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 1 *Job name:* Rack pad *D.O.T. No.* 604.280

Drawing Nos. 27, 28 *Time:* 2 hours

Objectives

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Turning
3. Taper turning
4. Measuring
5. Filing
6. Polishing

Equipment:

Lathe
Collet assembly
$\frac{1}{4}$" and $\frac{7}{8}$" collets
Toolholder and tool bits
1" micrometer
6" scale
Lathe file
Emery cloth

Materials

CRS SAE 1020, $\frac{7}{8}$" dia. x $1\frac{3}{8}$" long

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet assembly with $\frac{7}{8}$" collet and tighten workpiece to extend $\frac{7}{8}$".	
3. Face end to clean up.	
4. Rough turn $\frac{1}{4}$" dia. to $\frac{9}{32}$" dia. and face shoulder to $\frac{9}{16}$" length.	
5. Finish turn $\frac{1}{4}$" dia. and face shoulder to $\frac{9}{16}$" length.	
6. Turn compound 36° as in drawing, and turn taper to $\frac{1}{2}$" diameter.	6. Set compound angle from the lathe centerline.
7. Reverse workpiece and tighten in $\frac{1}{4}$" collet.	
8. Face end to overall length $1\frac{1}{16}$".	
9. Deburr and polish.	
10. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 2 *Job name:* Table *D.O.T. No.* 604.280

Drawing Nos. 27, 29 *Time:* 2 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Drilling
4. Reaming
5. Measuring
6. Filing
7. Polishing

Equipment:
Lathe
3-jaw chuck
Toolholder and tool bits
Center drill
Jacobs chuck
$\frac{15}{64}$" drill
$\frac{1}{4}$" reamer
1" micrometer
6" scale
Lathe file
Emery cloth

Materials
CRS SAE 1020, 2" dia. x $\frac{3}{4}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten workpiece with face extending $\frac{1}{8}$".	
3. Face end to clean up.	
4. Center drill.	
5. Drill $\frac{15}{64}$" hole through.	5. Use reamer as gage to check hole before drilling completely through.
6. Ream through with $\frac{1}{4}$" reamer.	
7. Chamfer 45° x $\frac{1}{16}$".	7. Extend on a parallel in order to clear for $\frac{1}{2}$" dimension. Tighten jaws and remove parallel.
8. Reverse workpiece and face to overall thickness $\frac{1}{2}$".	
9. Deburr and polish.	
10. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 3 *Job name:* Sleeve *D.O.T. No.* 604.280

Drawing Nos. 27, 30 *Time:* 3 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Drilling
4. Boring
5. Reaming
6. Filing
7. Polishing
8. Measuring

Equipment:
Lathe
Toolholder and tool bits
3-jaw chuck
Center drill
Jacobs chuck
$\frac{1}{4}$" and $\frac{23}{32}$" drills
$\frac{3}{4}$" reamer
$\frac{3}{4}$" mandrel
1-2" micrometer

Materials
CRS SAE 1020, $1\frac{1}{4}$" dia. x $1\frac{3}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten workpiece.	
3. Face end to clean up.	
4. Center drill.	
5. Drill through hole with $\frac{1}{4}$" drill.	
6. Drill through hole with $\frac{23}{32}$" drill.	
7. Mount boring tool and bore to $\frac{47}{64}$".	
8. Ream hole through with $\frac{3}{4}$" reamer.	
9. Reverse workpiece and face to $1\frac{9}{16}$" overall.	
10. Mount centers and drive plate, press $\frac{3}{4}$" mandrel into reamed hole, and position between centers.	
11. Rough turn outside diameter to $1\frac{3}{16}$".	11. Demonstrate that the dog clamps on the large end of the mandrel.
12. Finish turn outside diameter to 1.167".	
13. File bevel.	
14. Deburr and polish.	
15. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 4 *Job name:* Gear shaft *D.O.T. No.* 604.280

Drawing Nos. 27, 28 *Time:* 3 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Drilling
4. Tapping
5. Turning
6. Filing
7. Polishing

Equipment:
Lathe
Toolholder and tool bits
3-jaw chuck
Center drill
Jacobs chuck
No. 6 drill
$\frac{1}{4}$"-20 tap
Centers and drive plate
Drive dog
1-2" micrometer
6" scale
Lathe file
Emery cloth

Materials
CRS SAE 1020, $1\frac{1}{4}$" dia. x 3" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten work.	
3. Face end to clean up.	
4. Center drill.	4. Hold size of hole to $\frac{3}{8}$" dia. in order to retain a tapered seat after drilling.
5. Drill No. 6 hole, $\frac{3}{8}$" deep.	
6. Tap $\frac{1}{4}$"-20 x $\frac{1}{2}$" deep.	
7. Reverse work and face end to overall length $2\frac{27}{32}$".	7. $\frac{1}{2}$" will be removed after cutting the gear.
8. Center drill.	
9. Mount centers, drive plate, and clamp dog on the tapped end.	
10. Place between centers, rough turn .750" dia. to $\frac{13}{16}$", and face shoulder to $2\frac{1}{32}$" length.	
11. Finish turn .750" dia. and face shoulder to $2\frac{1}{16}$" length.	
12. Reverse workpiece and clamp dog on end.	12. Protect surface with soft material.
13. Rough turn 1.166" dia. to $1\frac{3}{16}$".	
14. Rough turn .500" dia. to $\frac{9}{16}$" and face shoulder to $\frac{1}{4}$".	
15. Finish turn 1.166" diameter to size.	
16. Finish turn .500" dia. to size and face shoulder to $\frac{9}{32}$".	
17. Deburr and polish.	
18. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 5A and 5B *Job name:* Handle and end *D.O.T. No.* 604.280

Drawing Nos. 27, 31 *Time:* $3\frac{1}{2}$ hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Center drilling
3. Drilling
4. Tapping
5. Counter boring
6. Taper turning
7. Forming
8. Filing
9. Polishing

Equipment:

Lathe
Toolholder and tool bits
Collet assembly, $\frac{3}{8}$", $\frac{5}{8}$" collets
Center drill
Jacobs chuck
No. 20 drill, No. 10 drill
10-32 UNF tap and cap screw
Tap wrench
Lathe file
Emery cloth
1" micrometer
6" scale
10-32 UNF counterbore

Materials

CRS SAE 1020, $\frac{3}{8}$" dia. x 5" long (1 required)
$\frac{5}{8}$" dia. x $\frac{5}{16}$" long (2 required)

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
Job 5A. Handle	
1. Select stock and deburr.	
2. Mount collet assembly with $\frac{3}{8}$" collet.	
3. Tighten workpiece and face end to clean up.	
4. Center drill.	
5. Drill No. 20 hole $\frac{3}{4}$" deep.	
6. Start 10-32 UNF tap square.	
7. Reverse workpiece and face end to $4\frac{7}{8}$" overall length.	
8. Center drill.	
9. Drill No. 20 hole $\frac{3}{4}$" deep.	
10. Start 10-32 UNF tap square.	10. Use shop procedure.
11. Finish hand tapping both ends with 10-32 UNF tap.	
12. Deburr and polish.	
13. Submit for inspection and grade.	
Job 5B. Handle end	
1. Select stock and deburr.	
2. Tighten workpiece in a $\frac{5}{8}$" collet and face end to clean up.	
3. Reverse workpiece and face to $\frac{15}{32}$" width.	
4. Center drill.	

5. Drill No. 10 hole through.
6. Counterbore $\frac{5}{16}$" diameter x $\frac{3}{16}$" deep.
6A. Countersink both ends $\frac{1}{32}$" deep.
7. Mount handle in $\frac{3}{8}$" collet and attach end with 10-32 UNF cap screw.
8. Turn compound 25° and turn taper to $\frac{3}{8}$" dia. on end
9. Turn compound 25° in the opposite direction and turn the taper to $\frac{3}{8}$" dia. on end.
10. File $\frac{1}{8}$" radii.
11. Deburr and polish.
12. Submit for inspection and grade.

Unit No. *Operator's job title:* Engine lathe operator

Project XIII *Project Name:* Arbor press

Job No. 6 *Job name:* Column *D.O.T. No.* 604.280

Drawing Nos. 27, 32 *Time:* 8 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Drilling
2. Boring
3. Reaming
4. Polishing

Equipment:
Lathe
4-jaw chuck
Indicator
Drills $\frac{1}{4}$", $\frac{15}{32}$", 1"
Toolholder, tool bits
$\frac{1}{2}$" reamer
Vernier calipers
1-2" micrometer
Lathe file
Emery cloth

Materials
CRS SAE 1020, 1" x $3\frac{1}{4}$" x 6" is milled to size. Counterbored hole 1.168" dia. is located by a center drilled hole.

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 4-jaw chuck and tighten workpiece to approximate location.	2. Use tailstock center to pick up center drilled hole.
3. Indicate center drilled hole until it runs concentric with the headstock bearing.	3. Note dotted line of counterbore designates an arbor press for right-handed operator.
4. Drill $\frac{1}{4}$" pilot hole through.	
5. Drill $\frac{15}{32}$" hole through.	
6. Drill 1" hole to $\frac{1}{2}$" depth.	6. Depth is measured at full diameter.
7. Mount boring tool and rough bore hole to 1.150" x $\frac{23}{32}$" depth.	
8. Finish bore 1.168" x $\frac{47}{64}$" depth.	8. Use mating part from Job No. 4 as a plug gage.
9. Bore .500" hole to .490".	
10. Ream .500" hole to size.	10. Fit mating part.
11. Deburr and polish.	
12. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XIV *Project Name:* Lathe mandrel

Job No. 1 *Job name:* Mandrel *D.O.T. No.* 604.280

Drawing No. 34 *Time:* 3 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Centering
3. Shoulder turning
4. Straight turning
5. Counterboring
6. Filing

Equipment:

Engine lathe	Tool bits
3-jaw chuck	Drill chuck
Lathe centers	Center drill
Drive plate	6" rule
Toolholder	1" micrometer

Materials
$\frac{7}{8}$" dia. x $6\frac{1}{4}$" tool steel

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	1. Identify correct sizes on the drawing for the part being made.
2. Locate workpiece in 3-jaw chuck and face end to clean up.	
3. Center drill to $\frac{1}{4}$" diameter.	3. Allow for $\frac{1}{32}$" counterbore to protect the center.
4. Counterbore $\frac{1}{32}$" deep x $\frac{7}{16}$" dia. with facing tool bit.	4. Explain that standard mandrels are made with a counterbore on the end to protect center hole.
5. Reverse workpiece and face to $6\frac{1}{8}$" overall length (A in drawing).	
6. Center drill and counterbore to size.	6. Hold dimensions to make both ends alike.
7. Set up lathe centers and drive plate, and mount workpiece between centers with lathe dog on one end.	
8. Turn C dia. to B length and chamfer end with a file.	8. Always mark the drawing to identify the sizes for the job.
9. Reverse workpiece with dog on turned end and turn C dia. to B length on other end.	
10. Turn nominal dia. to size +.025" for grinding.	
11. Deburr and polish.	
12. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XV *Project Name:* Lathe center, Morse taper

Job No. 1 *Job name:* Lathe center, No. 3 Morse taper *D.O.T. No.* 604.280

Drawing No. 35 *Time:* 4 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Center drilling
3. Straight turning
4. Taper turning
5. Filing

Equipment:

Engine lathe	Lathe dog
3-jaw chuck	Toolholder
Drill chuck	Tool bits
Lathe centers	Center drill
Drive plate	File

Materials
Tool steel 1" dia. x $5\frac{3}{4}$" long

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr sharp edges.	1. Pick dimensions desired from drawing.
2. Mount in 3-jaw chuck, face and center drill end.	2. Hold size of center hole to $\frac{3}{16}$" dia.
3. Reverse workpiece, face to $5\frac{3}{16}$" length and center drill.	3. Repeat these operations if making more than one piece.
4. Set up lathe centers and drive plate.	4. Check center alignment and concentricity.
5. Locate dog on workpiece, mount on centers and turn point end to $\frac{1}{2}$" dia. x $\frac{1}{2}$" long.	
6. Turn D dia. leaving .025" grinding stock.	
7. Set compound to 30° off centerline and machine shoulder to angle.	
8. Reverse part and relocate dog on point end.	
9. Turn E diameter to $\frac{5}{8}$" x $\frac{1}{4}$" long.	9. Be sure tool bit is on center for taper turning. Check taper with gage and adjust attachment for correct fit.
10. Set taper attachment to .602" per foot and turn	
11. Deburr and polish.	
12. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XVI *Project Name:* Grinding vise

Job No. 1 *Job name:* Lead screw nut *D.O.T. No.*604.280

Drawing Nos. 36, 37 *Time:* $2\frac{1}{2}$ hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Straight turning
3. Center drilling
4. Drilling
5. Tapping

Equipment:
Engine lathe
3-jaw chuck
Toolholder and tool bits
6" scale
0-1" micrometer
Center drill
F-size drill
$\frac{5}{16}$"-18 UNC tap
Collet assembly
$\frac{9}{16}$" collet

Materials
CRS SAE 1020 $1\frac{1}{4}$" dia. x 2" long

Selected References:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount 3-jaw chuck and tighten workpiece to extend $1\frac{3}{8}$" from jaw.	
3. Take facing cut to clean up ends.	
4. Rough turn .560" dia. to .590" and face shoulder to 1.300".	
5. Finish turn $\frac{.560}{.562}$" dia. and face shoulder to 1.320".	
6. Center drill.	
7. Drill F-size to .650" depth.	7. Summarize how to get depth settings by using tailstock scale.
8. Countersink $\frac{1}{16}$" deep.	
9. Tap $\frac{1}{4}$"-20 UNC to .500" depth.	
10. Mount collet assembly with $\frac{9}{16}$" collet.	
11. Tighten workpiece and face end to .115" shoulder dimension.	
12. File all burrs and polish.	
13. Submit for inspection and grade.	

Unit No. *Operator's job title:* Engine lathe operator

Project XVI *Project Name:* Grinding vise

Job No. 2 *Job name:* End nut

Drawing Nos. 36, 38 *D.O.T. No.* 604.280

Time: 2 hours

Objectives:
Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations
1. Facing
2. Turning
3. Drilling
4. Tapping
5. Polishing

Equipment:
Engine lathe
Collet attachment
$\frac{1}{2}$" collet
0-1" micrometer
$\frac{1}{4}$"-20, and $\frac{5}{16}$"-24 LH taps
No. 7 and Letter "I" drills
Toolholder and tool bits
Tap wrench

Materials
Drill rod $\frac{1}{2}$" dia. x $1\frac{5}{8}$"

Selected references:
Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*

1. Select stock and deburr..
2. Mount collet assembly with $\frac{1}{2}$" collet.
3. Tighten stock, extending it by $1\frac{1}{8}$", and take facing cut to clean up.
4. Finish turn to .490" dia.
5. Center drill.
6. Drill No. 7 hole through.
7. Drill Letter "I" hole to .670" depth.
8. Tap $\frac{5}{16}$"-24 LH to $\frac{1}{2}$ " depth.
9. Tap $\frac{1}{4}$"-20 through.
10. Deburr and polish.
11. Reverse workpiece and cut off end to $1\frac{1}{16}$" length.
12. Face end to overall length .990".
13. Deburr and polish.
14. Submit for inspection and grade.

Unit No. *Operator's job title:* Engine lathe operator

Project XVI *Project Name:* Grinding vise

Job No. 3 *Job name:* Lead screw *D.O.T. No.*604.280

Drawing Nos. 36, 38 *Time:* 3 hours

Objectives:

Using the equipment, materials, and operations listed here, the student will be able to produce the piece shown on the drawing in accordance with the time and accuracy requirements specified.

Operations

1. Facing
2. Turning
3. Threading
4. Chamfering
5. Drilling

Equipment:

Engine lathe
Collet assembly
$\frac{5}{16}$" and $\frac{7}{16}$" collets
Toolholder and tool bits
Center drill
Jacobs chuck
$\frac{3}{16}$" and No. 3 drills
0-1" micrometer
6" scale
Vernier caliper

Materials

Drill rod
$\frac{7}{16}$" dia. x $4\frac{1}{2}$" long

Selected references:

Machining Fundamentals by Walker, and Machine Tool Technology by McCarthy & Smith

PROCEDURE	*TECHNIQUES AND RELATED INFO.*
1. Select stock and deburr.	
2. Mount collet assembly with $\frac{7}{16}$" collet.	
3. Extend work $\frac{1}{2}$" and tighten in collet.	
4. Take facing cut to clean up.	
5. Center drill.	
6. Extend work $3\frac{3}{4}$", support with tailstock center, and tighten collet.	
7. Rough turn $\frac{5}{16}$" dia. to .340" and face shoulder to 3.715".	7. $\frac{1}{4}$" will be removed later to eliminate center.
8. Finish turn $\frac{5}{16}$" dia. to .312" and face shoulder to 3.715".	
9. Set up lathe for threading left-hand $\frac{5}{16}$"-24 UNF thread.	
10. Thread $\frac{1}{4}$" of shoulder and fit to nut.	10. Follow shop procedure.
11. Extend threaded section through $\frac{5}{16}$" collet to $\frac{1}{2}$" length and tighten.	
12. Face off $\frac{1}{4}$" to 3.465 dimension.	
13. Deburr and chamfer slightly to eliminate crossthread at front end.	
14. Reverse workpiece and face end to .315" dimension.	
15. Finish turn .430" dia.	
16. Center drill.	
17. Drill $\frac{3}{16}$" hole .200" deep.	
18. Drill No. 3 hole .200" deep.	
19. Deburr and polish.	
20. Submit for inspection and grade.	

Bibliography

Anderson, James & Tatro, Earl E. Shop theory; 5th ed. New York, N.Y. McGraw-Hill. 1968.

Burghardt, Henry D., Axelrod, Aaron, & Anderson, James. Machine tool operation. Part 1, 5th ed., 1959; Part 2, 4th ed., 1960. New York, N.Y. McGraw-Hill.

Fairer, John L. & Tatro, Earl E. Machine tool metalworking: principles & practice. New York, N.Y. McGraw-Hill. 1961.

Johnson, Harold V. General-industrial machine shop; Rev. ed. Peoria, Ill. Chas. A. Bennett Co. 1970.

Jones, Franklin D. Machine shop training course, 2 vols.; 5th ed. New York, N.Y. Industrial Press. 1964.

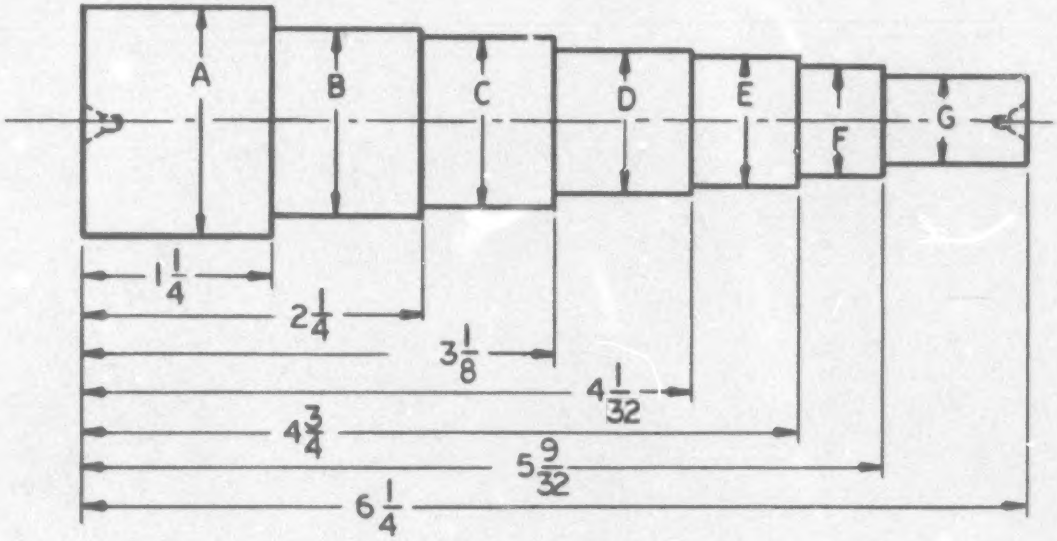
McCarthy, Willard J. & Smith, Robert E. Machine tool technology; 3rd ed. Bloomington, Ill. McKnight & McKnight. 1968.

Porter, Harold W., Lascoe, Orville D., & Nelson, Clyde A. Machine shop operations and setups; 3rd ed. Chicago, Ill. American Technical Society. 1967.

Walker, John R. Machining fundamentals. Homewood, Ill. Goodheart-Willcox Co. 1969.

Drawings for Shop Projects

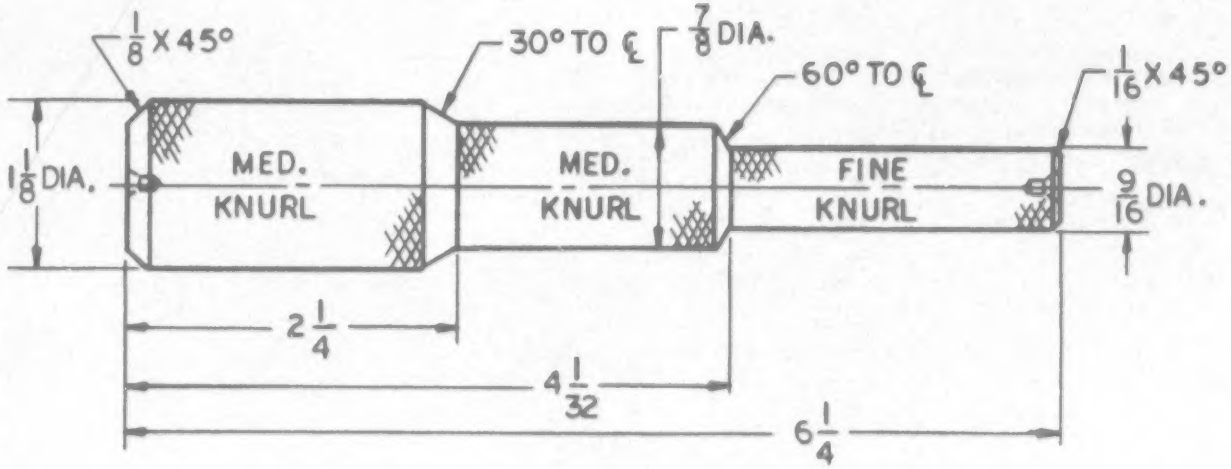
91



JOB NO.	A	B	C	D	E	F	G
1	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$\frac{15}{16}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$
2	1.450	1.207	1.079	.901	.806	.687	.577

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
$\pm\frac{1}{64}$ ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

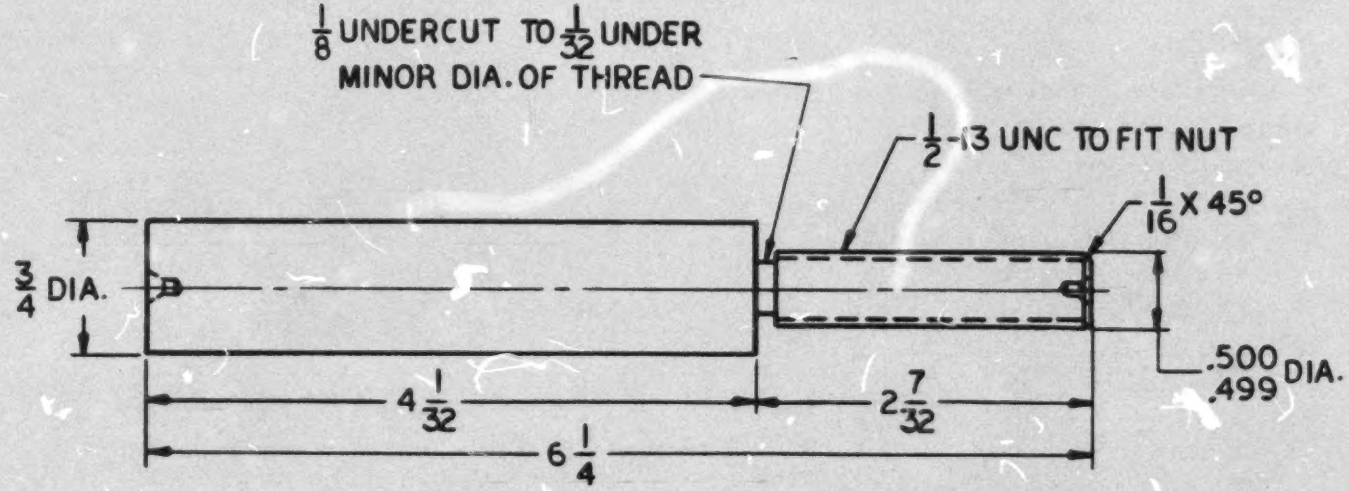
DRAWN BY: E.F.S.	MULTI-DIAMETER SHAFT	
SCALE: ———	STEP TURNING: RULE & MICROMETER SIZES	DWG. NO. 1



83

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

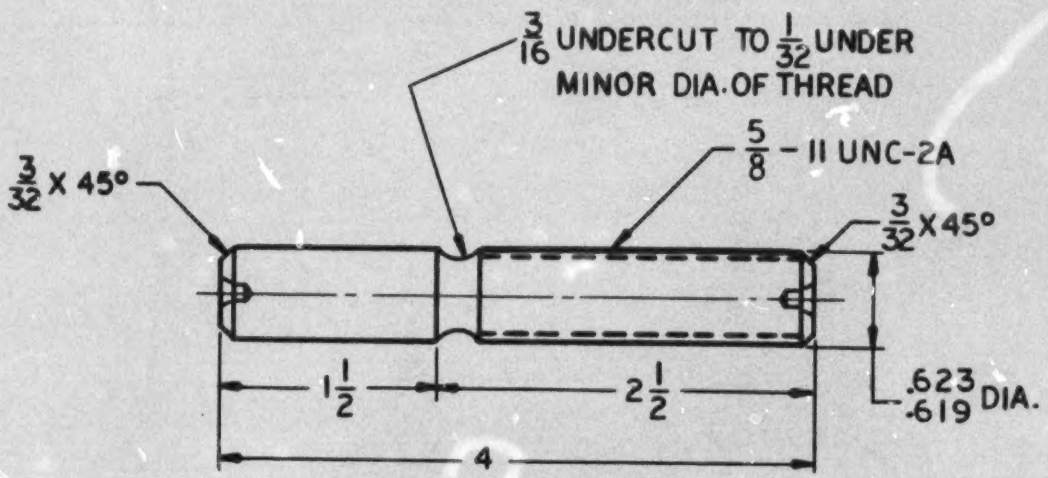
DRAWN BY: EFS	MULTI-DIAMETER SHAFT	
SCALE: ———	KNURLED CHAMFERED SHAFT	DWG. NO. 2



84

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

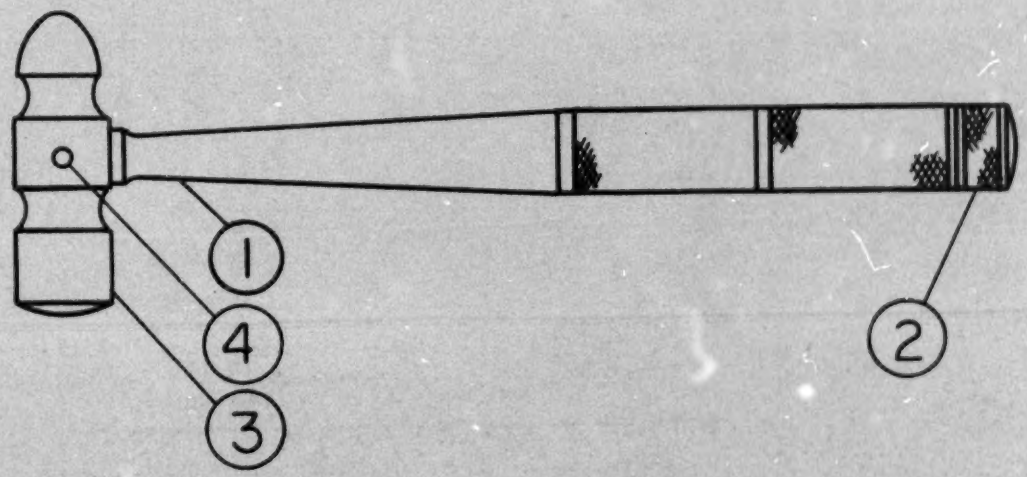
DRAWN BY: E.F.S.	MULTI-DIAMETER SHAFT	
SCALE: ——	DIE THREADING AND UNDERCUTTING	DWG.NO. 3



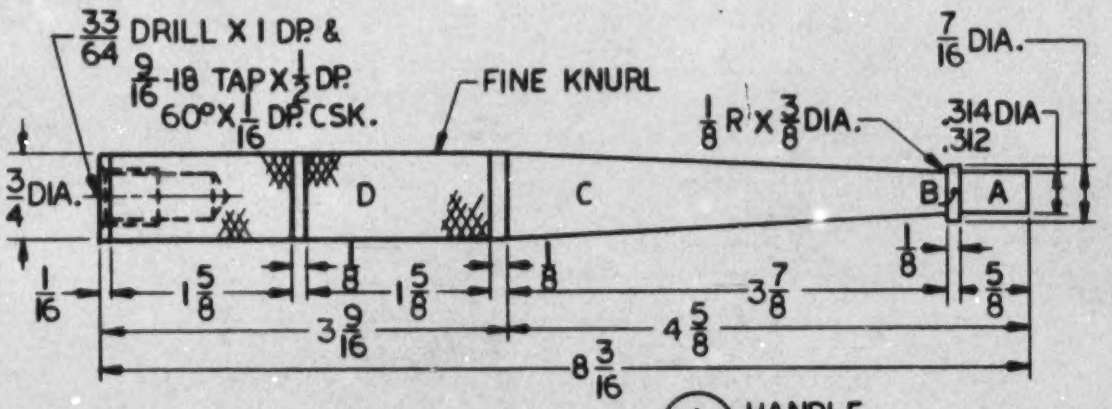
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	MULTI-DIAMETER SHAFT	
SCALE: ———	THREAD TURNING	DWG. NO. 4

85



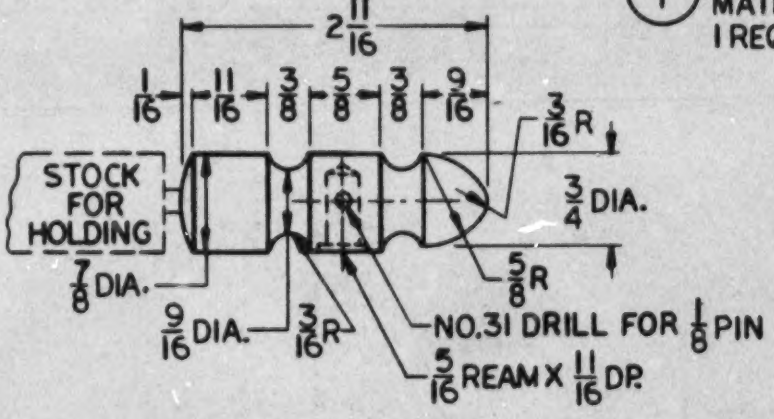
DRAWN BY: EFS	BALL PEEN HAMMER ASSEMBLY	
SCALE: ——		DWG. NO. 5



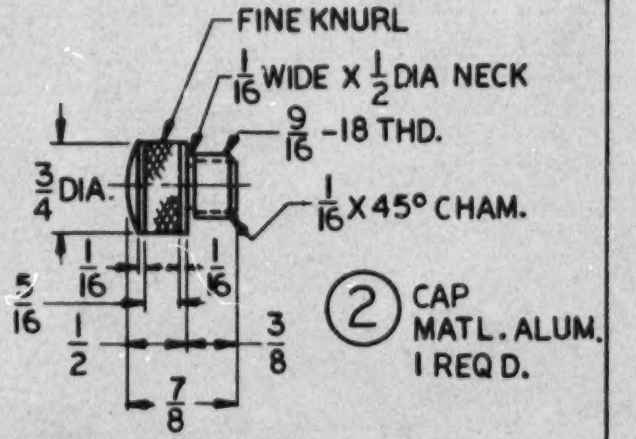
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

NOTES:
HEAT TREATMENT:
HARDEN TEMPER HEAD PT. 3
FINISH: POLISH

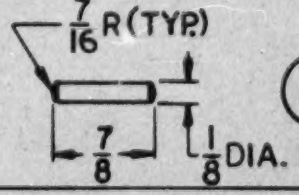
(1) HANDLE
MATL. ALUM.
1 REQD.



(3) HEAD
MATL. CRS
1 REQD.

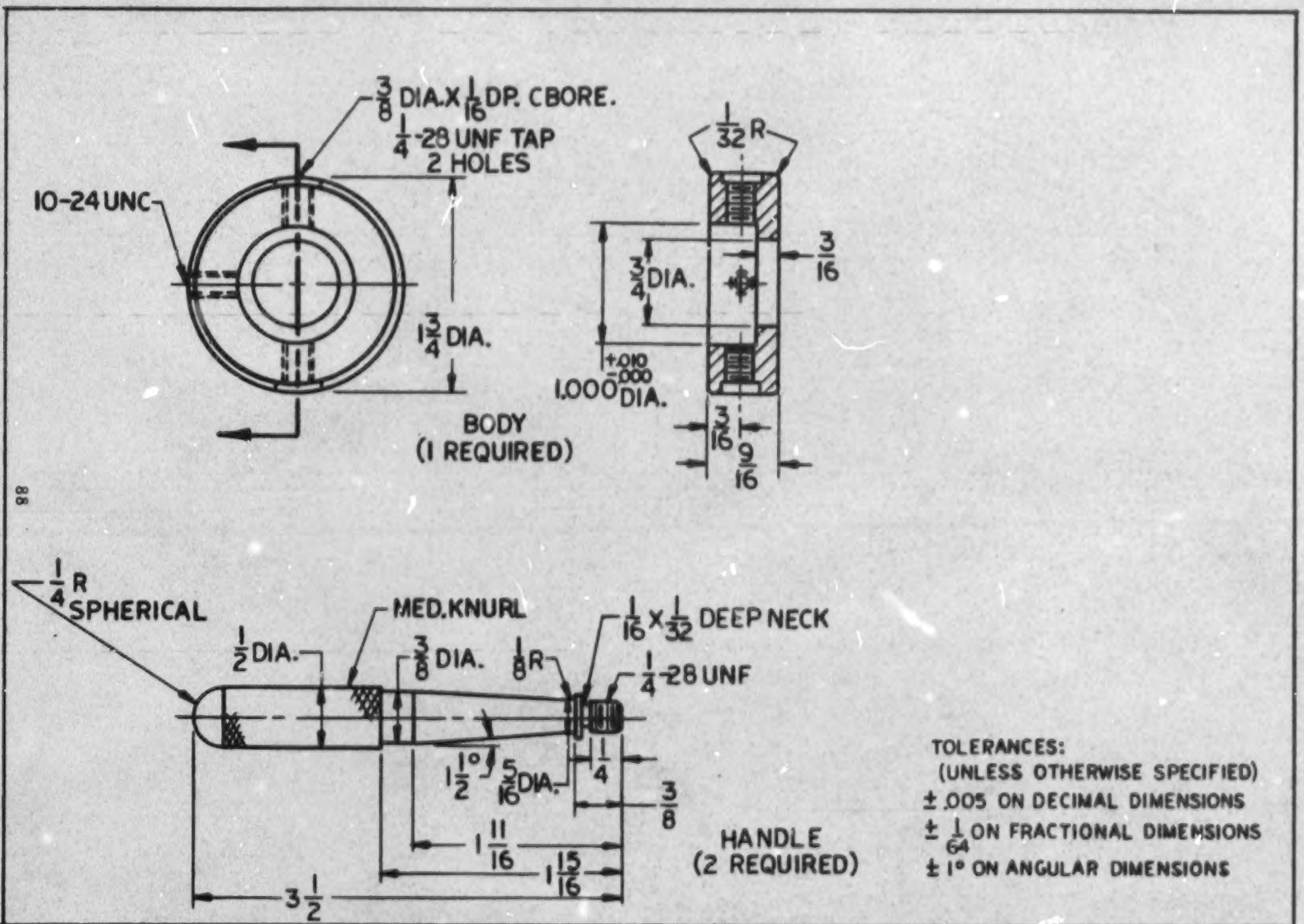


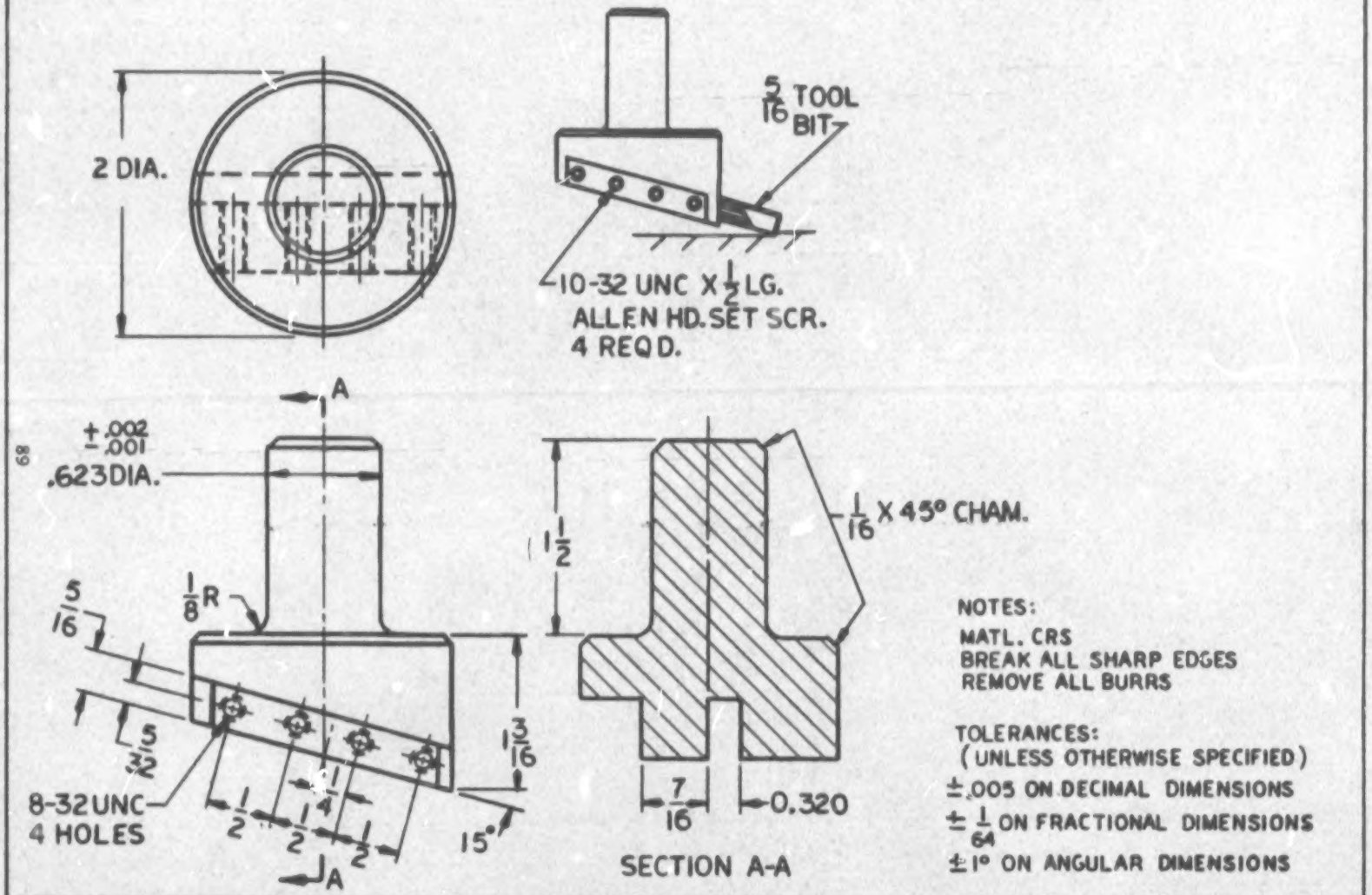
(2) CAP
MATL. ALUM.
1 REQ D.

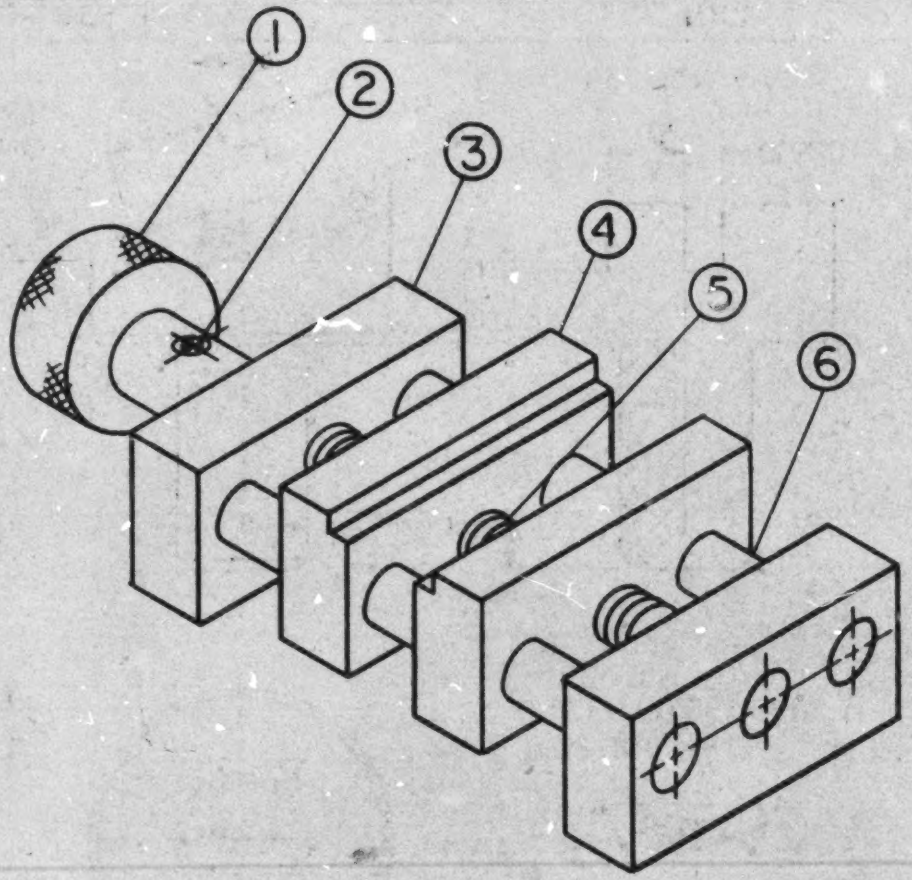


(4) PIN
MATL. CRS
1 REQ D.

DRAWN BY: E.F.S.	BALL PEEN HAMMER DETAILS	
SCALE: ——		DWG. NO. 6

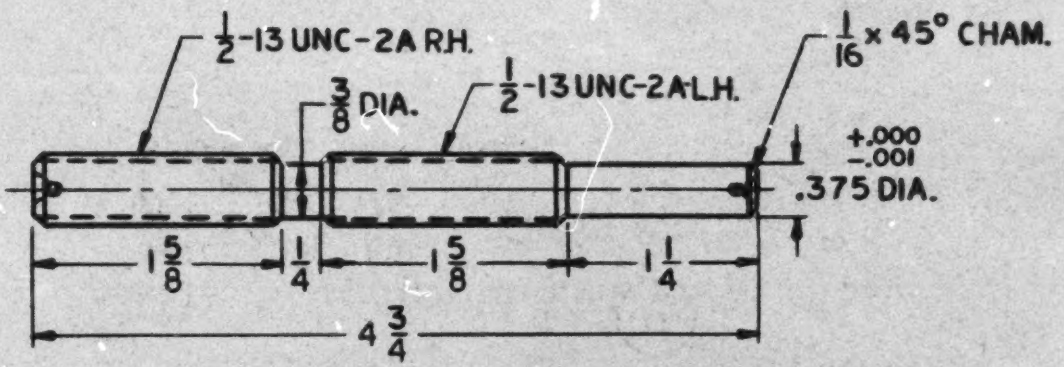

3/8 DIA. X 1/16 DP. CBORE.
1/4-28 UNF TAP
2 HOLES
10-24 UNC
1 3/4 DIA.
BODY
(1 REQUIRED)
1/32 R
3/4 DIA.
3/16
1.000 +.010 -.000 DIA.
3/16
9/16
88
1/4 R
SPHERICAL
MED. KNURL
1/16 X 1/32 DEEP NECK
1/2 DIA.
3/8 DIA.
1/8 R
1/4-28 UNF
1 1/2
1°
5/16 DIA.
1/4
3/8
1 11/16
1 15/16
3 1/2
HANDLE
(2 REQUIRED)
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
DIE WRENCH
DWG. NO. 7


2 DIA.
5/16 TOOL BIT
10-32 UNC X 1/2 LG.
ALLEN HD. SET SCR.
4 REQD.
A
+.002 -.001
.623 DIA.
1/8 R
5/16
5/32
8-32 UNC
4 HOLES
1/2
1/4
1/2
1/2
15°
1 3/16
A
1 1/2
1/16 X 45° CHAM.
7/16
0.320
SECTION A-A
NOTES:
MATL. CRS
BREAK ALL SHARP EDGES
REMOVE ALL BURRS
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
FLY TOOL
FACE CUTTER
DWG. NO. 8



PARTS LIST			
NO.	NAME	MATL.	REQD.
1	KNURLED HDL.	CRS	1
2	SET SCREW	STL.	3
3	END PIECE	CRS	2
4	VISE JAWS	CRS	2
5	ACT. SCREW	CRS	1
6	GUIDE ROD	CRS	2

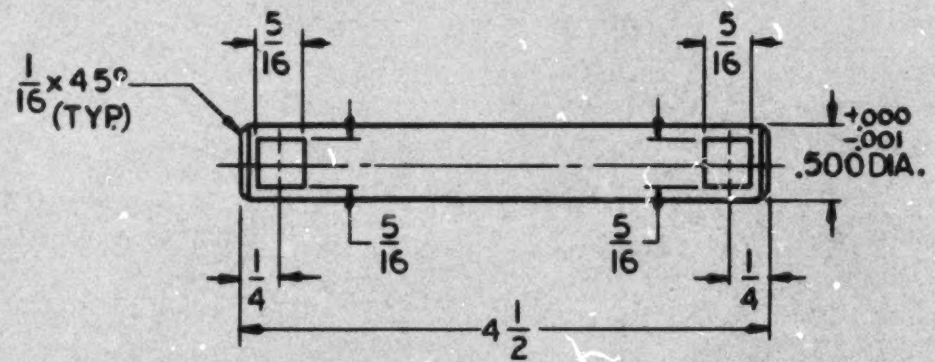
DRAWN BY: E.F.S.	SELF-CENTERING VISE ASSEMBLY	
SCALE: ——		DWG. NO. 9



(5)

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	SELF-CENTERING VISE	
SCALE: ——	JAW-ACTUATING SCREW	DWG. NO. 10



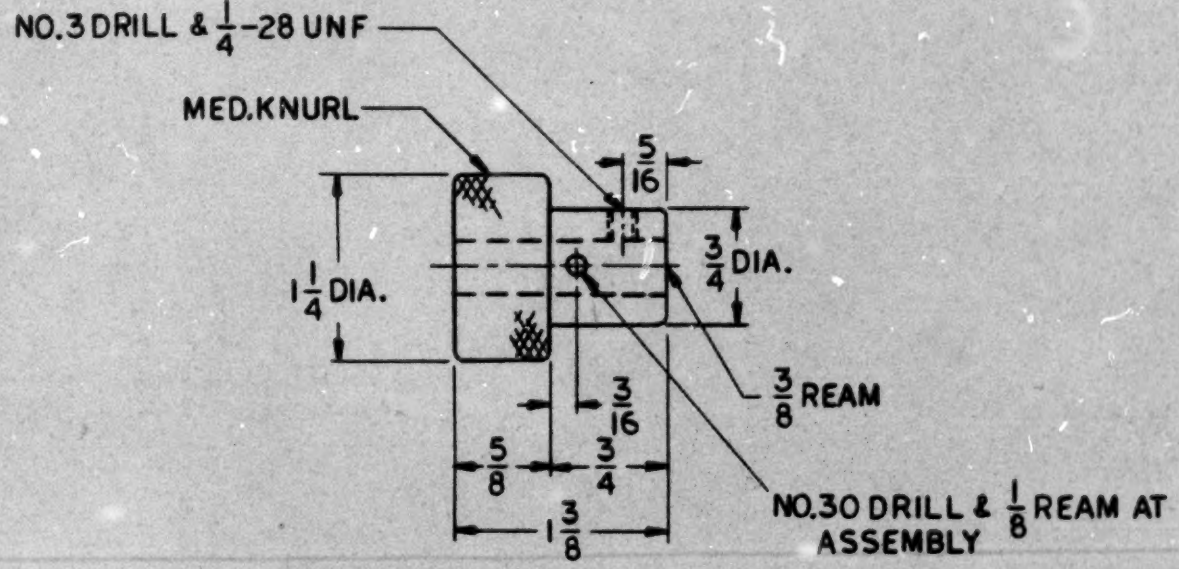
6

NOTES:
MATL. $\frac{1}{2}$ DIA. CRS
FILE $\frac{5}{16}$ SQ. FLATS
BREAK ALL SHARP EDGES

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± $\frac{1}{64}$ ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	SELF-CENTERING VISE GUIDE ROD	
SCALE: ——		DWG. NO. 11

92



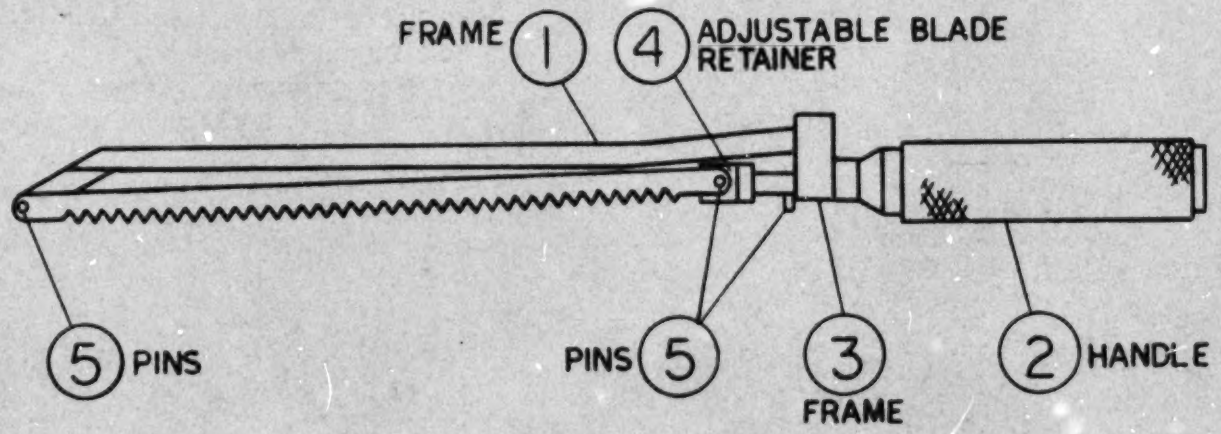
93

(1)

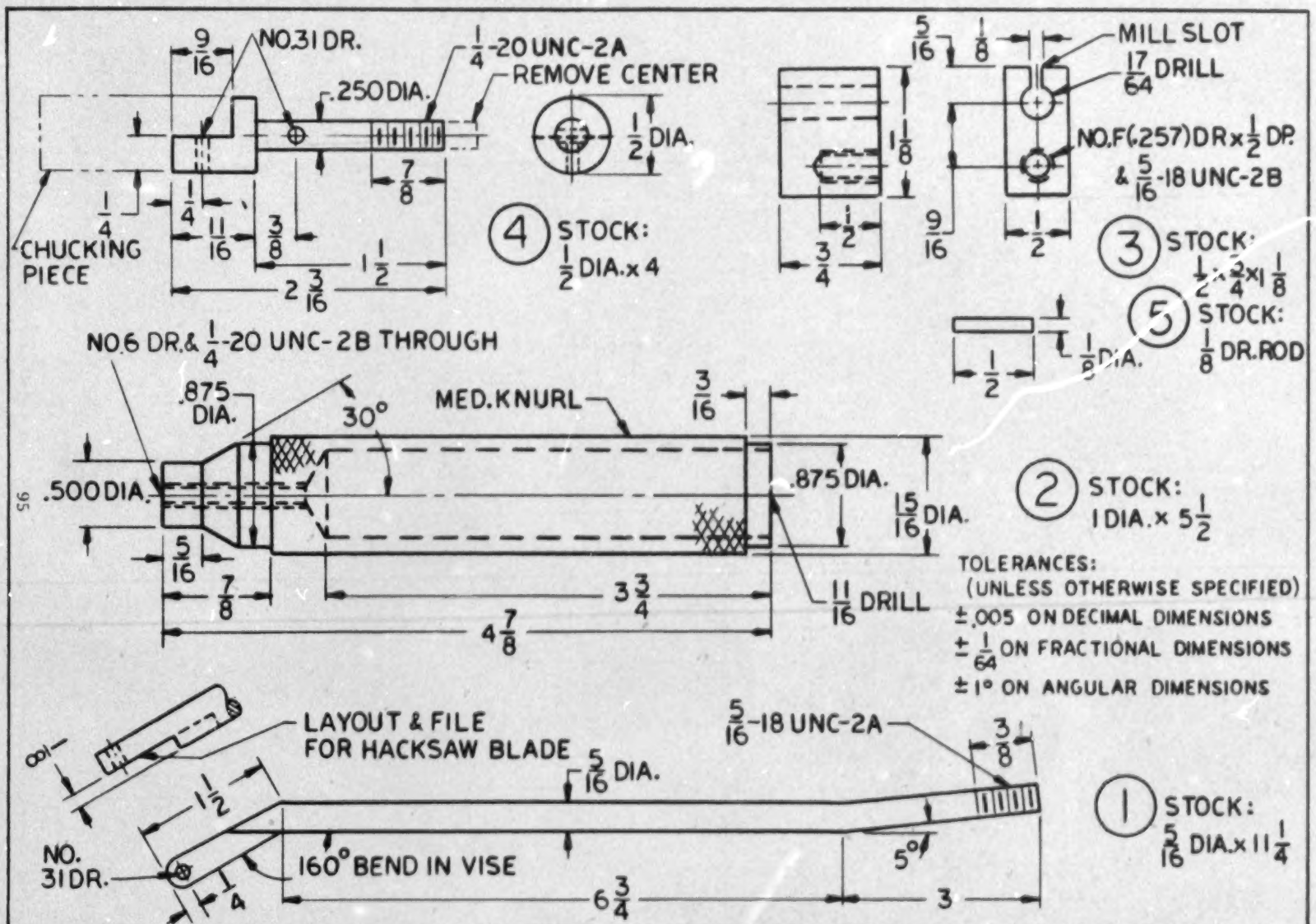
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

MATL. ALUM.

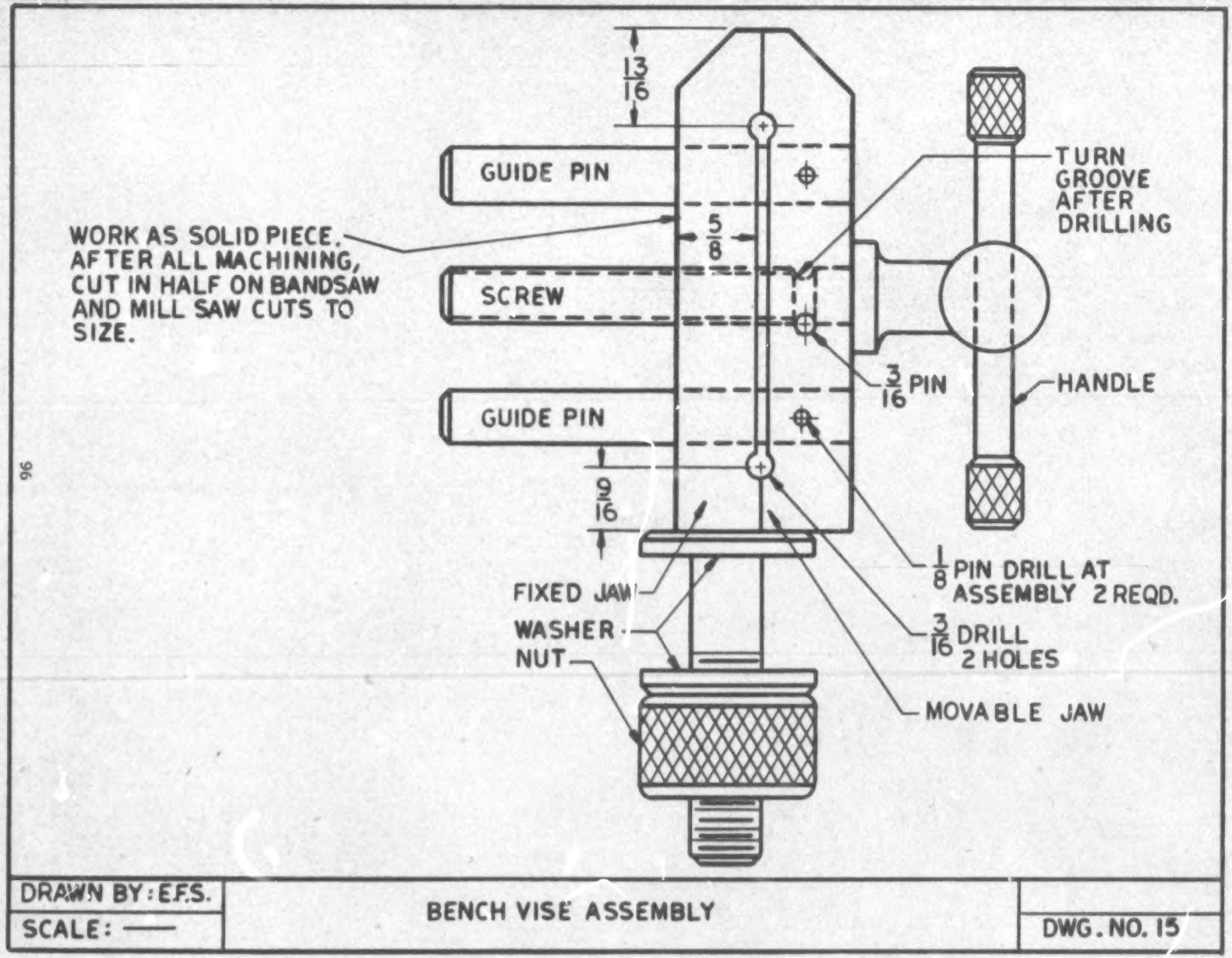
DRAWN BY: E.F.S.	SELF-CENTERING VISE	
SCALE: ——	KNURLED HANDLE	DWG. NO. 12



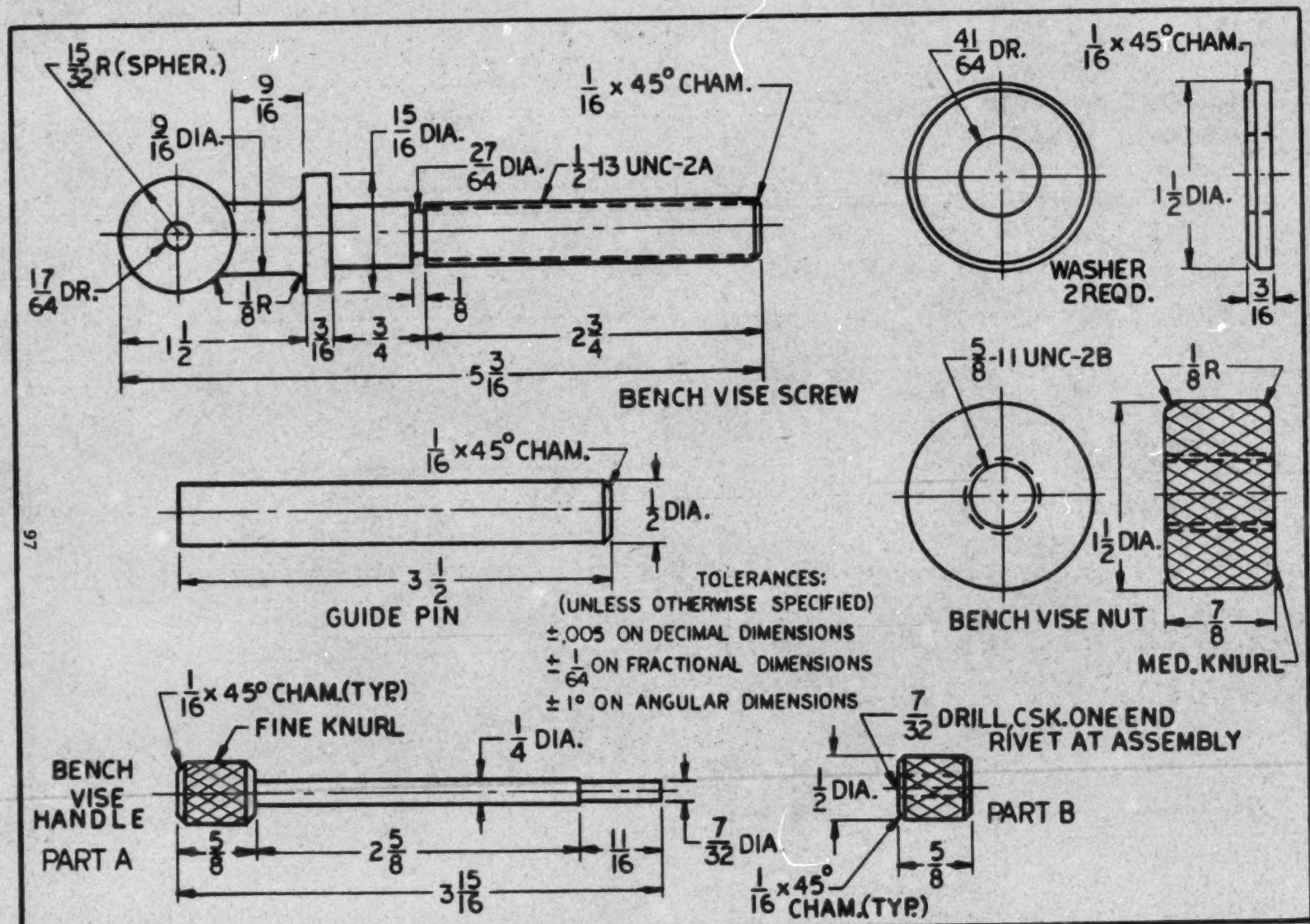
DRAWN BY: E.F.S.	CLOSE QUARTERS HACKSAW ASSEMBLY	
SCALE: ——		DWG. NO. 13



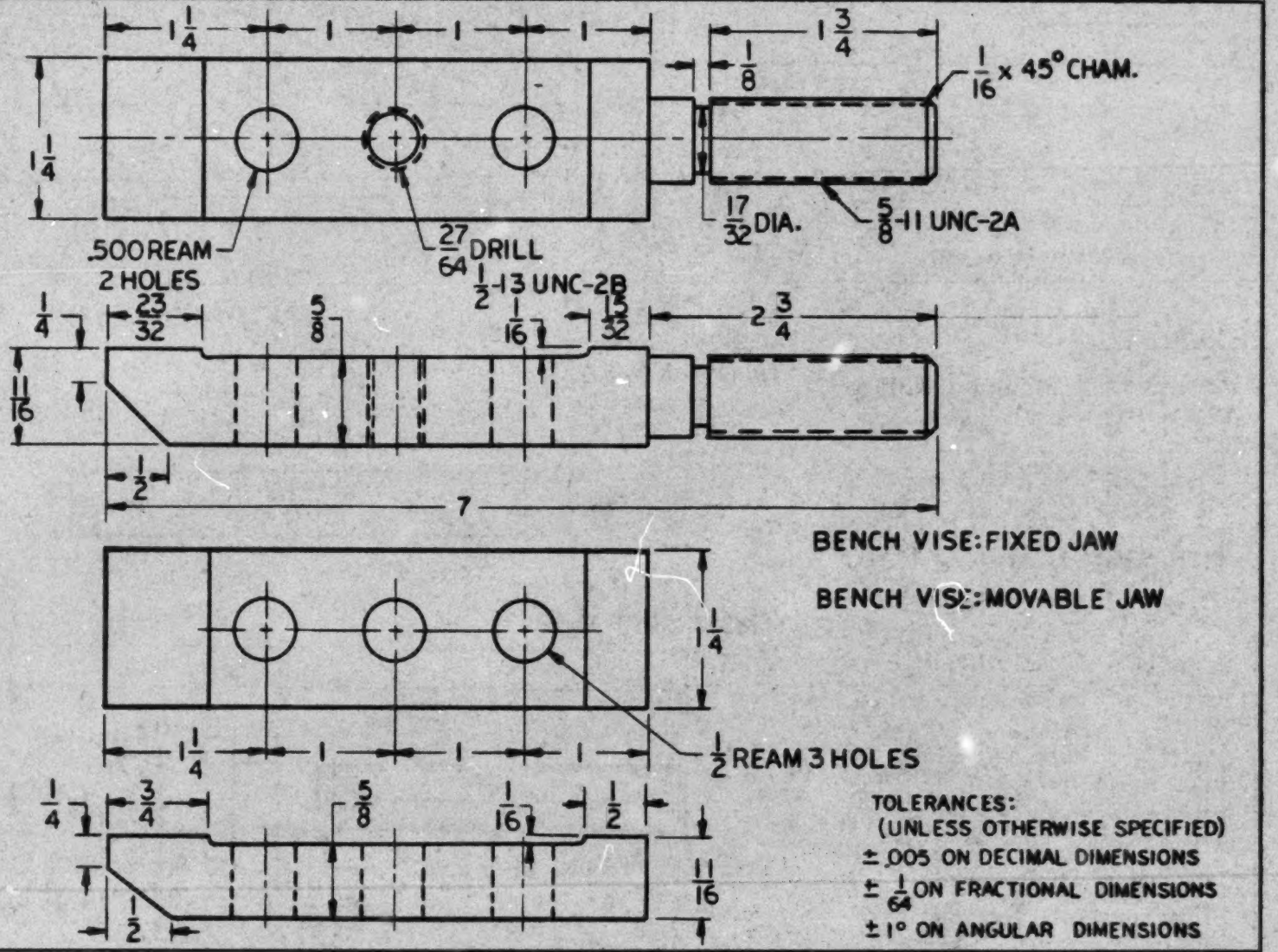
DRAWN BY: E.F.S.	CLOSE QUARTERS HACKSAW DETAILS	
SCALE: ——		DWG. NO. 14



DRAWN BY: E.F.S.	BENCH VISE ASSEMBLY	
SCALE: ——		DWG. NO. 15

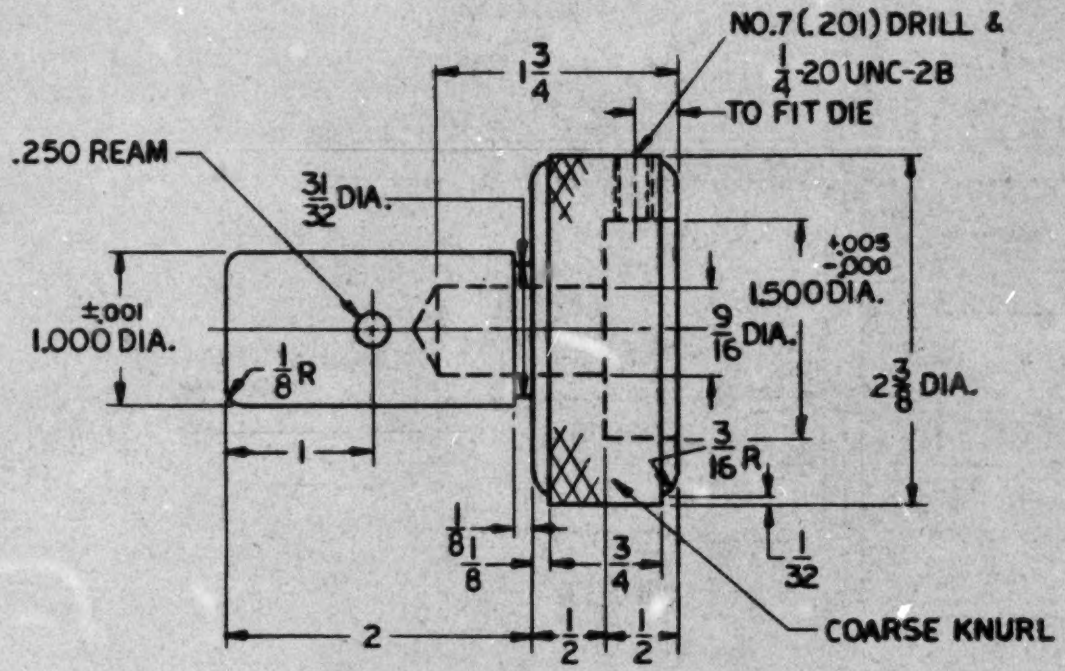


DRAWN BY: E.F.S.	BENCH VISE DETAILS	
SCALE: ——		DWG. NO. 16



TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS

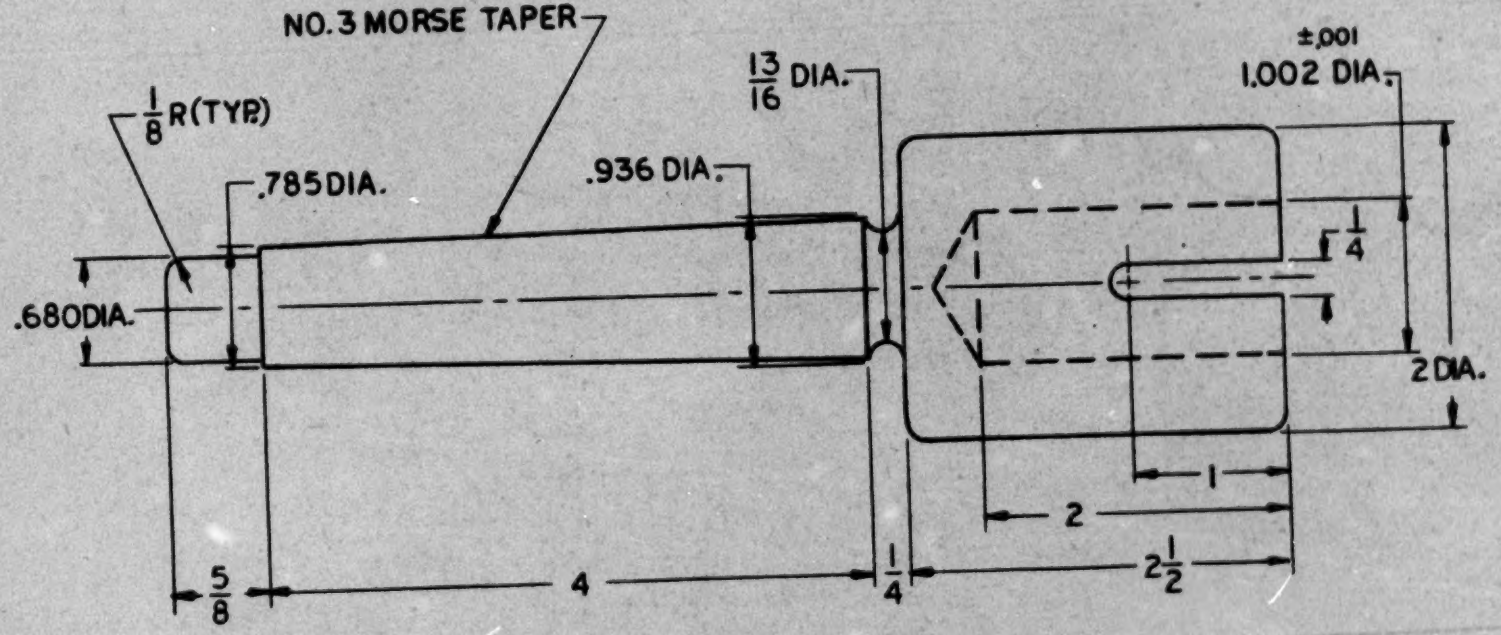
DRAWN BY: E.F.S.	BENCH VISE FIXED AND MOVABLE JAWS	
SCALE: ——		DWG. NO. 17



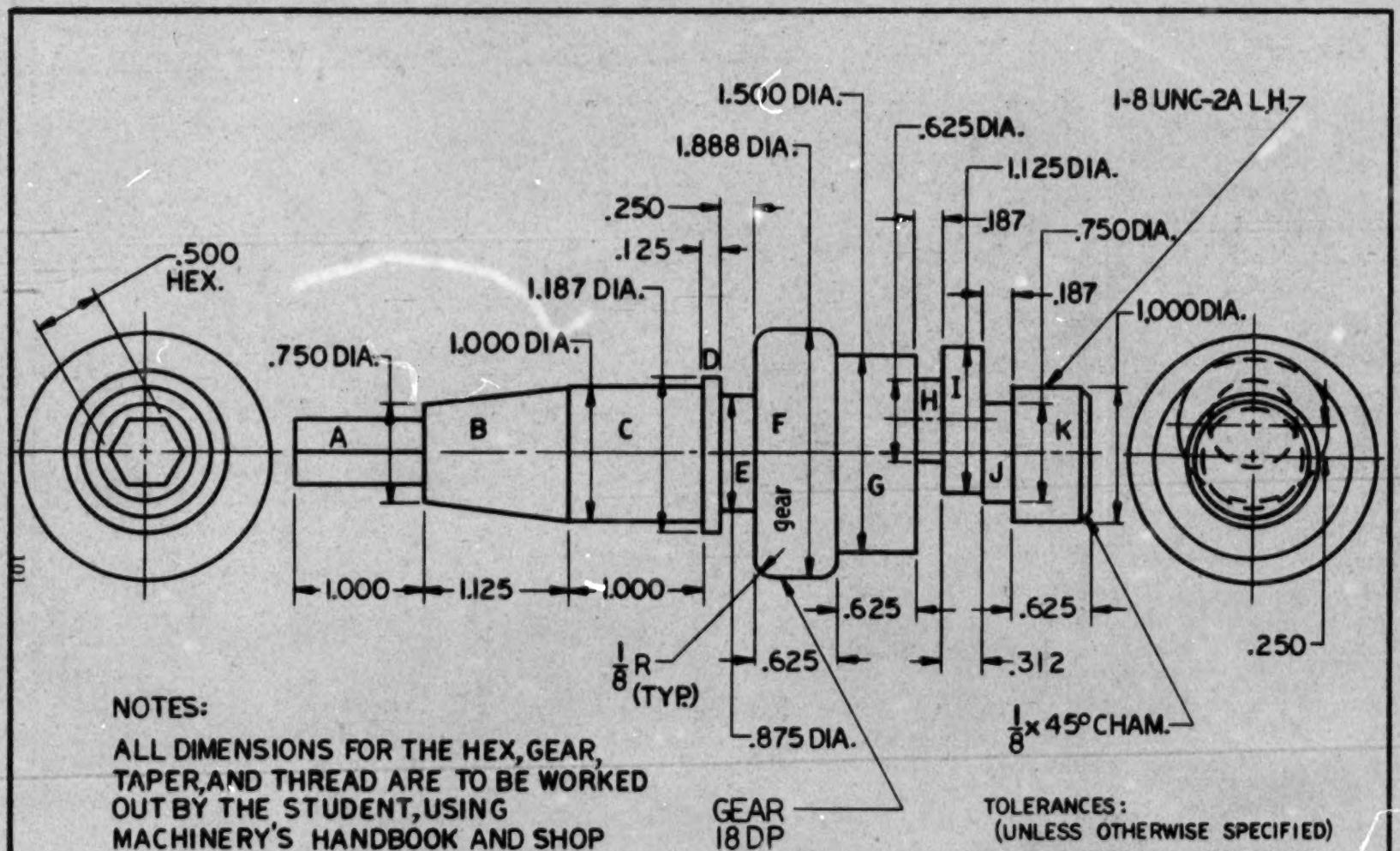
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

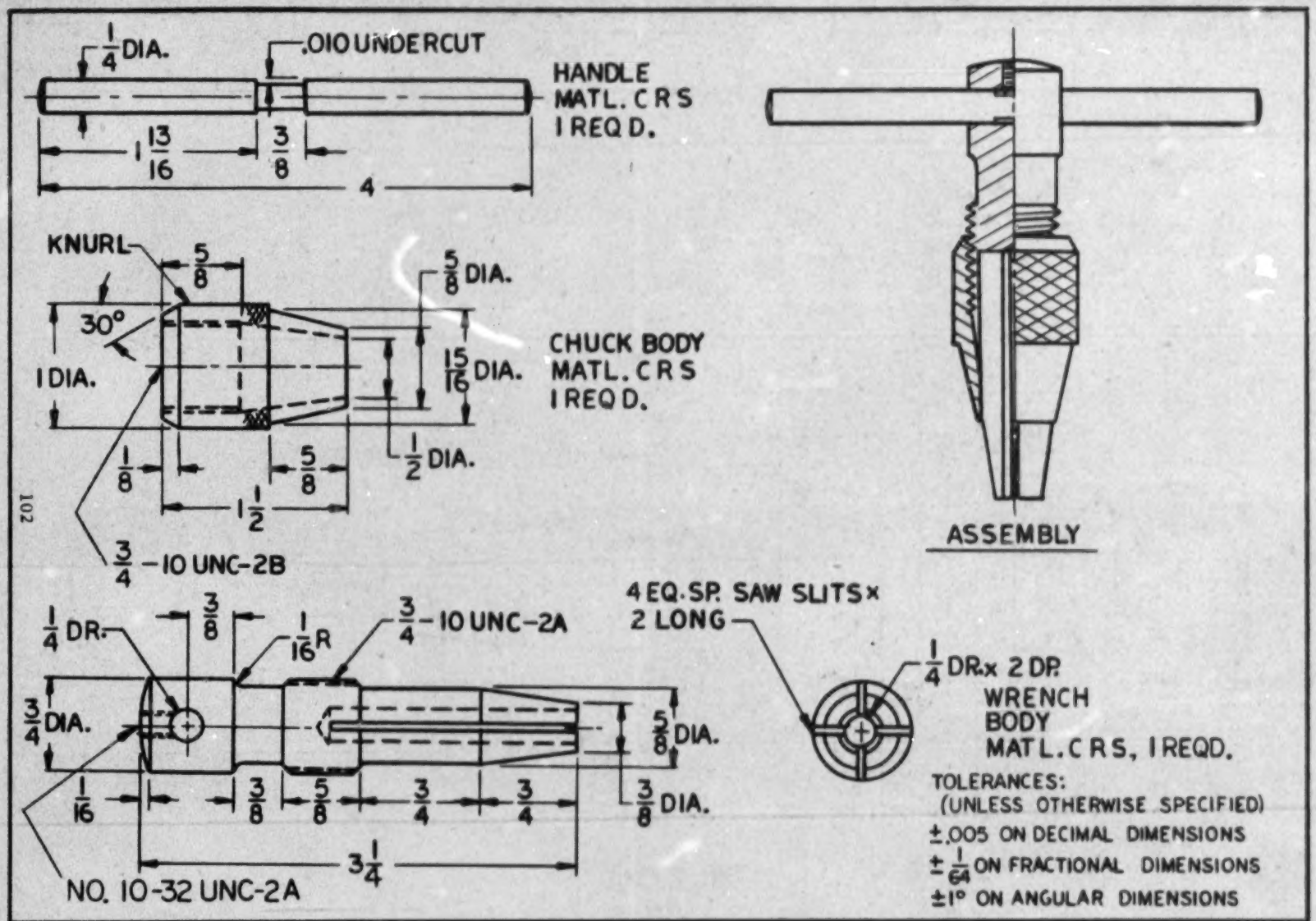
DRAWN BY: E.F.S.	LATHE DIEHOLDER	
SCALE: ——	SLIDING HOLDER	DWG. NO.18

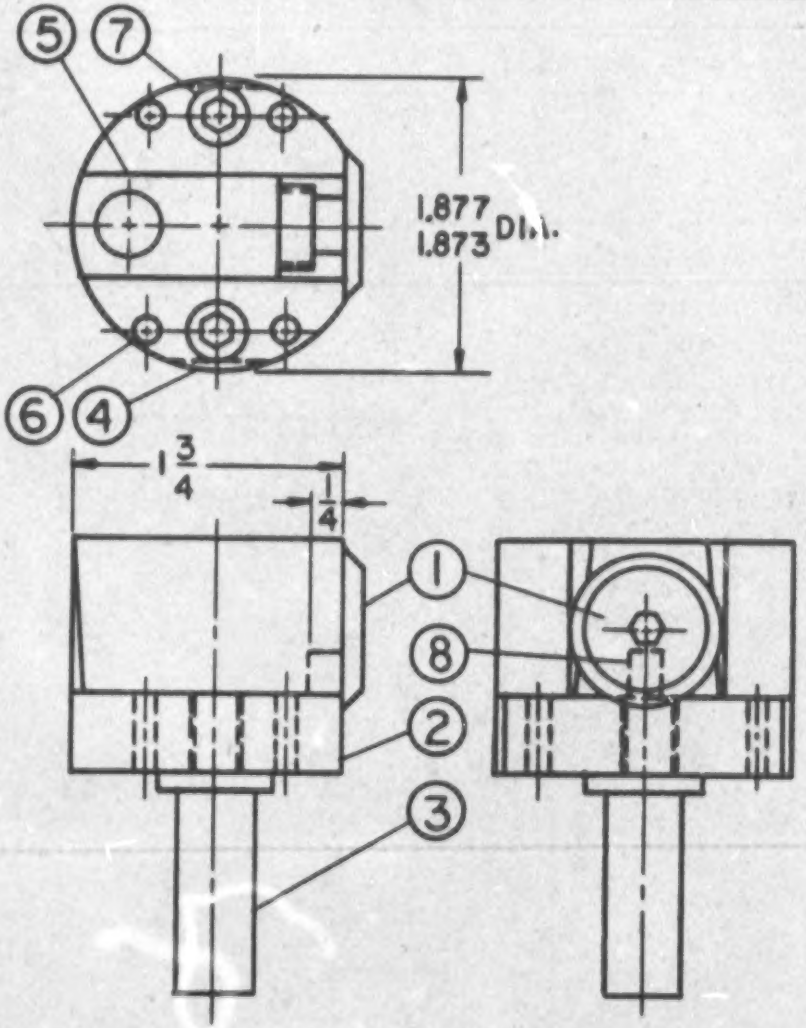
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
$\pm\frac{1}{64}$ ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS



DRAWN BY: E.F.S.	LATHE DIEHOLDER TAPERED SHANK SUPPORT	
SCALE: ——		DWG. NO. 19


1.500 DIA.
1.888 DIA.
.625 DIA.
1.125 DIA.
1-8 UNC-2A L.H.
.250
.125
.187
.750 DIA.
.187
1.187 DIA.
1.000 DIA.
.500 HEX.
.750 DIA.
1.000 DIA.
D
A
B
C
F
E
gear
G
H
I
J
K
1.000
1.125
1.000
.625
.625
.250
1/8 R (TYP.)
.625
.312
.875 DIA.
1/8 x 45° CHAM.
NOTES:
ALL DIMENSIONS FOR THE HEX, GEAR, TAPER, AND THREAD ARE TO BE WORKED OUT BY THE STUDENT, USING MACHINERY'S HANDBOOK AND SHOP NOTEBOOK.
GEAR
18 DP
32 TEETH
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
ECCENTRIC TEST SHAFT
DWG. NO. 20


1/4 DIA.
.010 UNDERCUT
HANDLE
MATL. C R S
1 REQ D.
1 13/16
3/8
4
KNURL
5/8
5/8 DIA.
30°
1 DIA.
15/16 DIA.
CHUCK BODY
MATL. C R S
1 REQ D.
1/2 DIA.
1/8
5/8
1 1/2
3/4 - 10 UNC-2B
ASSEMBLY
4 EQ. SP. SAW SLITS x
2 LONG
1/4 DR. x 2 DP.
WRENCH
BODY
MAT L. C R S, 1 REQD.
1/4 DR.
3/8
1/16 R
3/4 - 10 UNC-2A
3/4 DIA.
5/8 DIA.
3/8 DIA.
1/16
3/8
5/8
3/4
3/4
3 1/4
NO. 10-32 UNC-2A
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
TAP WRENCH
DWG. NO. 21

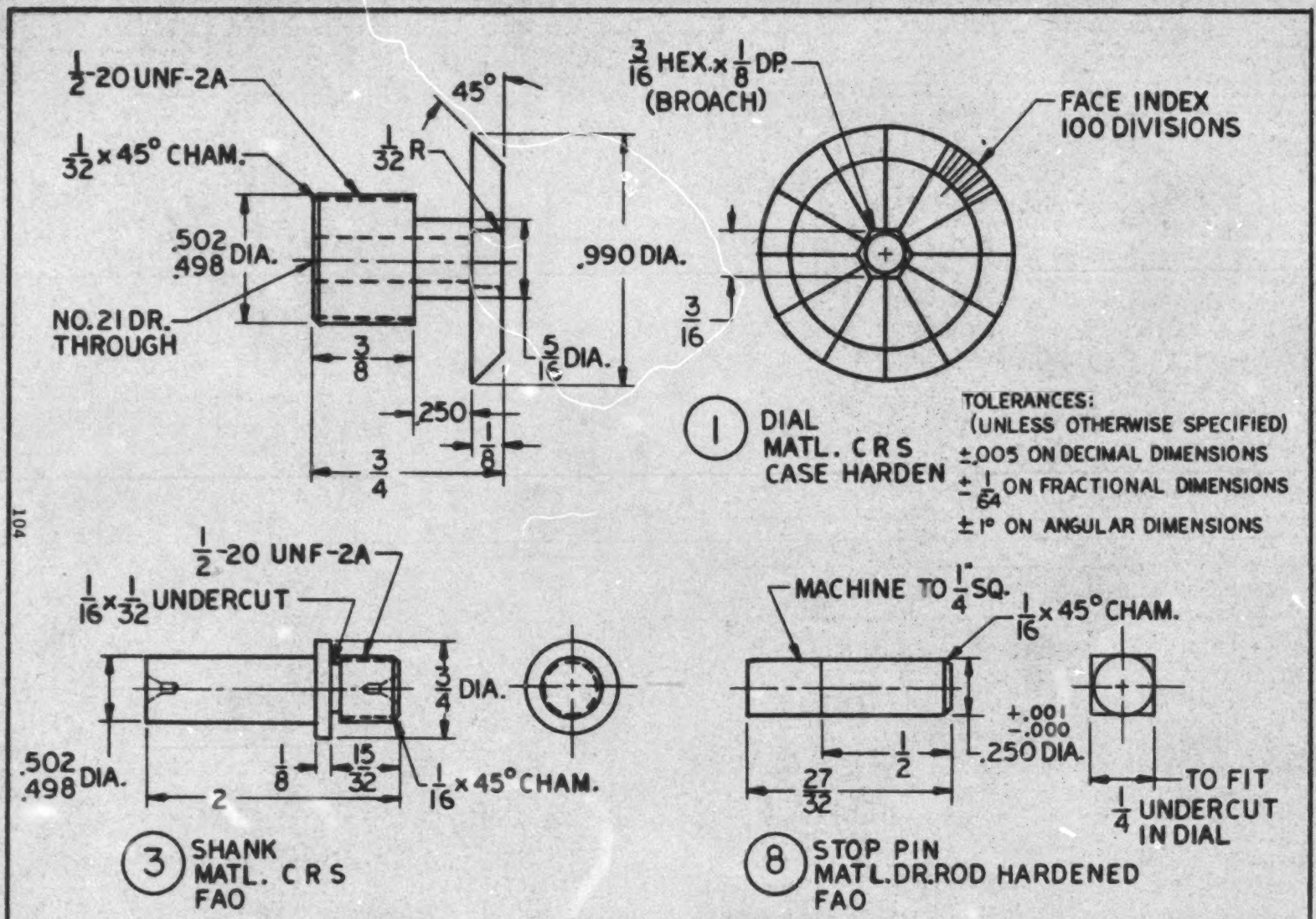


PARTS LIST			
NO.	NAME	MATL.	REQD.
1	GRADUATED DIAL	C R S	1
2	PLATE	C R S	1
3	SHANK	C R S	1
4	DOVETAIL BLOCKS	C R S	2
5	DOVETAIL SLIDE	C R S	1
6	DOWEL PIN $\frac{3}{16}$ DIA. x $1\frac{1}{4}$	C R S	4
7	HEX. HD. CAP SCR. $\frac{5}{16}$-18 UNC	C R S	2
8	STOP PIN	C R S	1

NOTES:

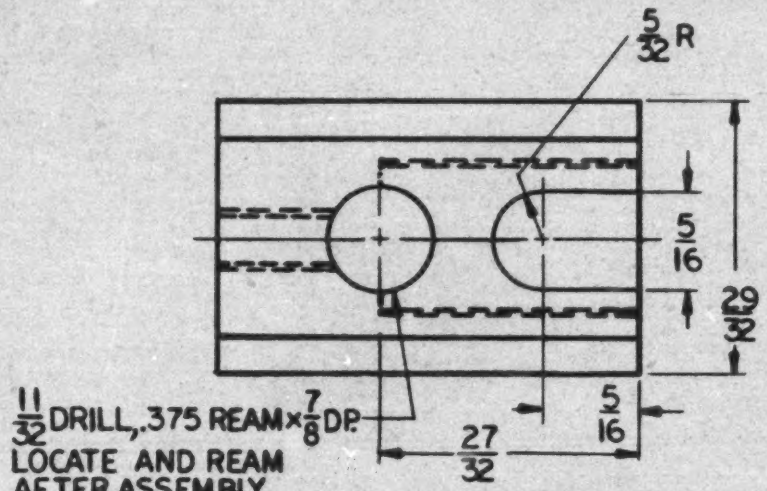
1. PARTS 2 AND 4 ARE MILLING MACHINE PROJECTS.
2. PARTS 6 AND 7 ARE PURCHASED.
3. PARTS 2, 4 AND 5 ARE ASSEMBLED TO A 2" SQ. AND THEN MACHINED ROUND.

DRAWN BY: E.F. S.	MICROMETER BORING HEAD ASSEMBLY	
SCALE: ——		DWG. NO. 22

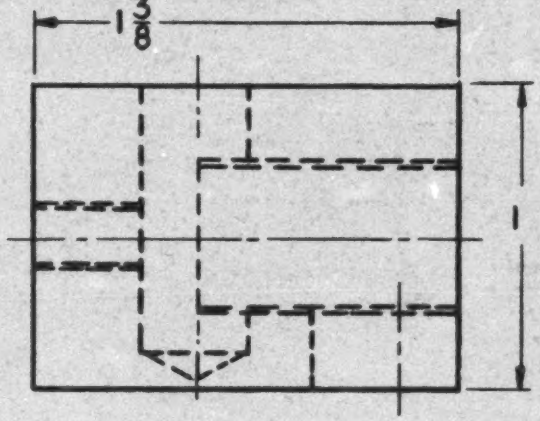


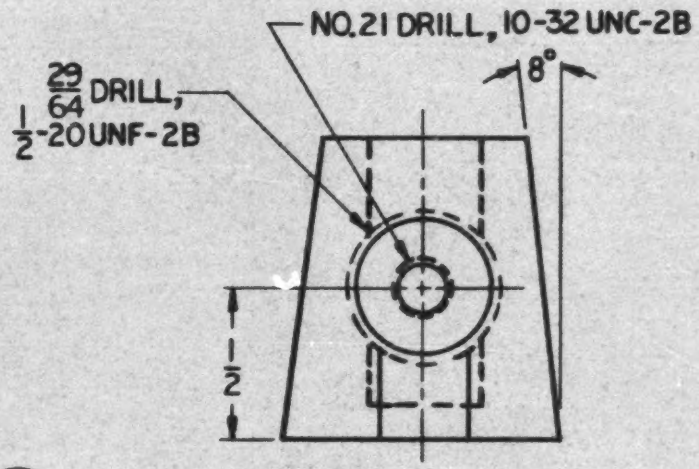
DRAWN BY : E.F.S.	MICROMETER BORING HEAD	
SCALE : ——	DIAL, SHANK, AND STOP PIN	DWG. NO. 23

104



TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS



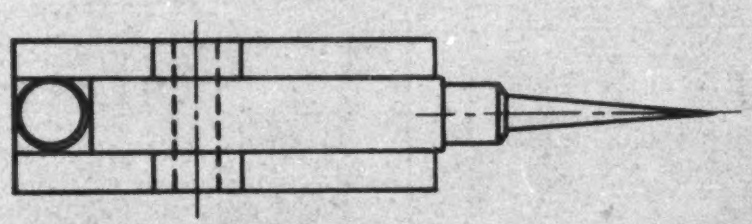


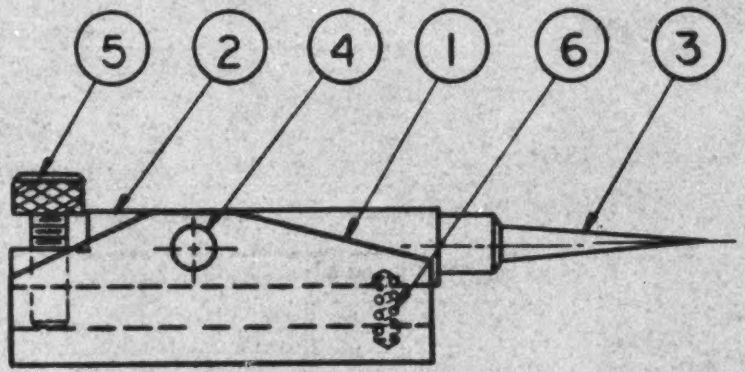
(5) DOVETAIL SLIDE
MATL. CRS
FAO

DRAWN BY: E.F.S.	MICROMETER BORING HEAD	
SCALE: ——	DOVETAIL SLIDE	DWG. NO. 24

105

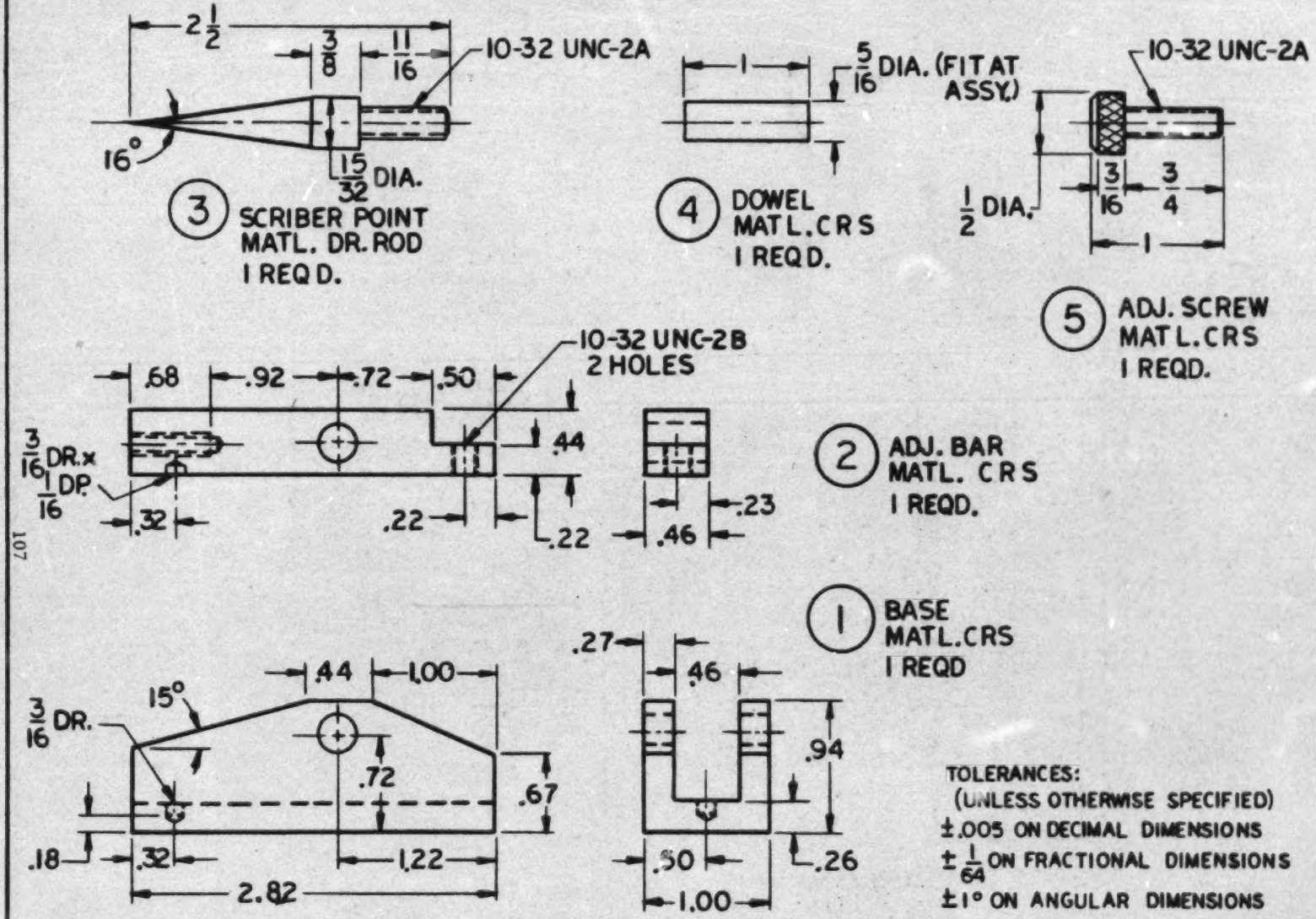
PARTS LIST			
NO.	NAME	MATL.	REQD.
1	BASE $\frac{15}{16} \times 1 \times 2\frac{7}{8}$	CRS	1
2	ADJUSTMENT BAR	CRS	1
3	SCRIBER PT. $\frac{3}{8}$ D×2$\frac{5}{8}$	DR	1
4	DOWEL PIN $\frac{5}{16}$ D×1	CRS	1
5	ADJ. SCREW	CRS	1
6	SPRING TO SUIT	STD.	1

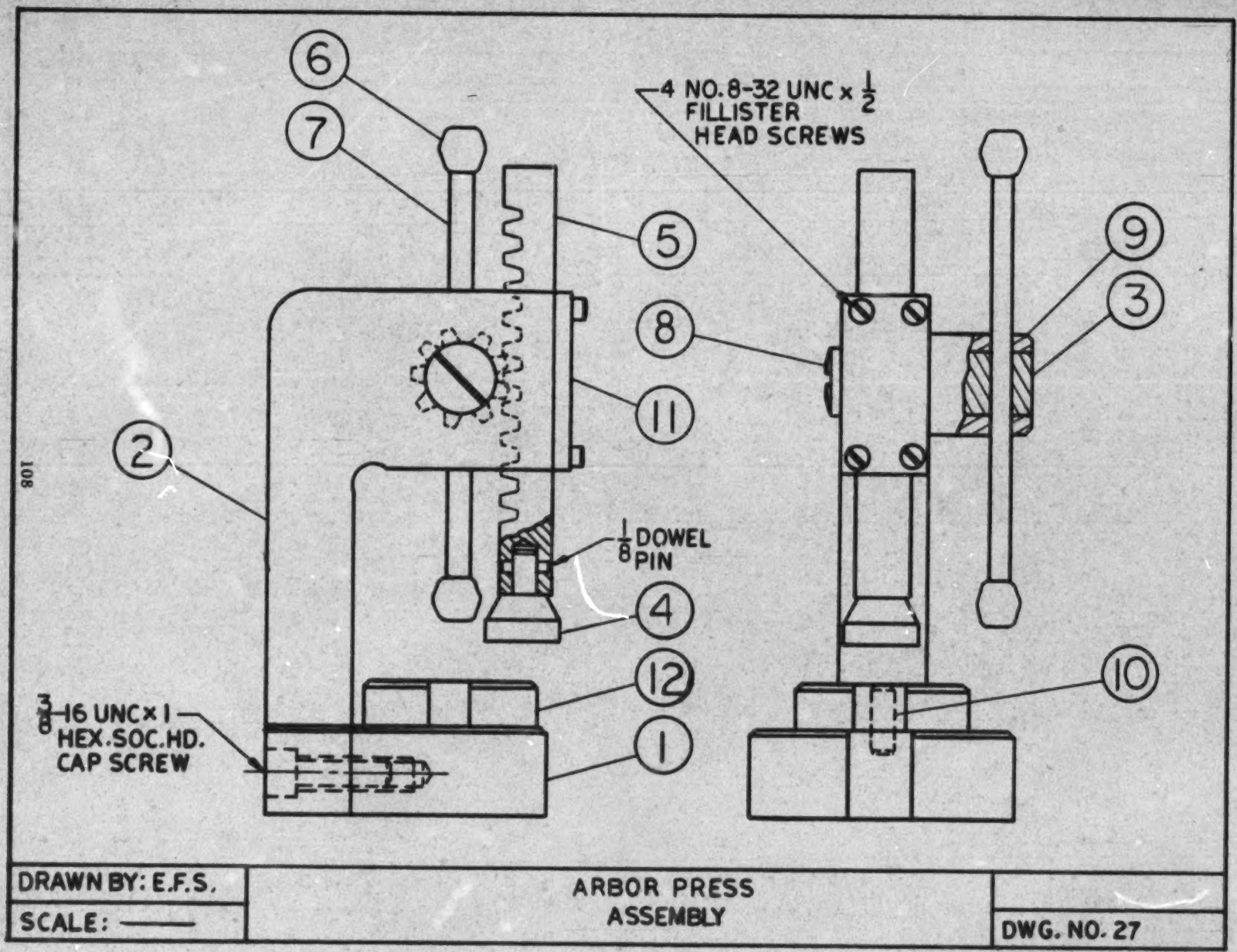




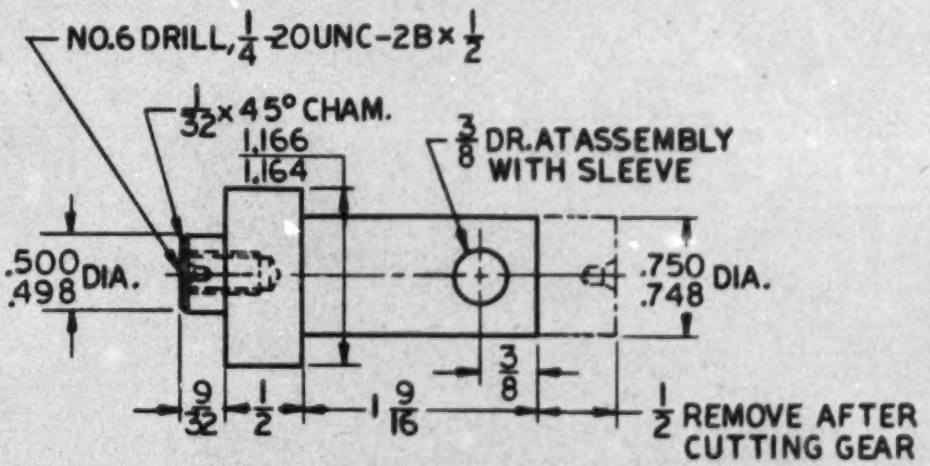
106

DRAWN BY: E.F.S.	SURFACE GAGE ASSEMBLY	
SCALE: ——		DWG.NO. 25


2 1/2
3/8
11/16
10-32 UNC-2A
16°
15/32 DIA.
3 SCRIBER POINT MATL. DR. ROD 1 REQ D.
1
5/16 DIA. (FIT AT ASSY.)
4 DOWEL MATL. CRS 1 REQD.
10-32 UNC-2A
1/2 DIA.
3/16
3/4
1
5 ADJ. SCREW MATL. CRS 1 REQD.
10-32 UNC-2B 2 HOLES
.68
.92
.72
.50
.44
3/16 DR. x 1/16 DP.
.32
.22
.22
.46
.23
2 ADJ. BAR MATL. CRS 1 REQD.
107
.44
1.00
15°
3/16 DR.
.72
.67
.18
.32
1.22
2.82
.27
.46
.94
.50
.26
1.00
1 BASE MATL. CRS 1 REQD
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
SURFACE GAGE DETAILS
DWG. NO. 26

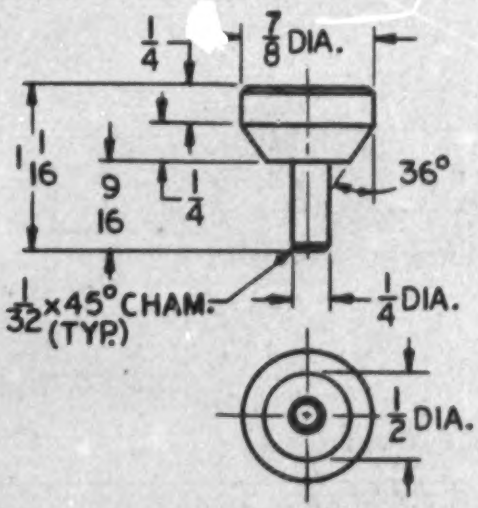


DRAWN BY: E.F.S.	ARBOR PRESS ASSEMBLY	
SCALE: ——		DWG. NO. 27

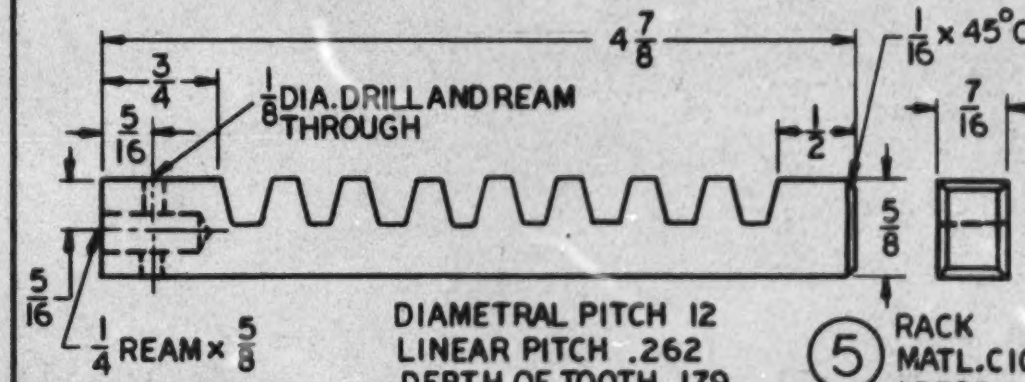


DIAMETRAL PITCH 12
NO. OF TEETH 12

(3) GEAR SHAFT
MATL. C1010
1 REQD.



(4) RACK PAD
MATL. C1020
1 REQD.

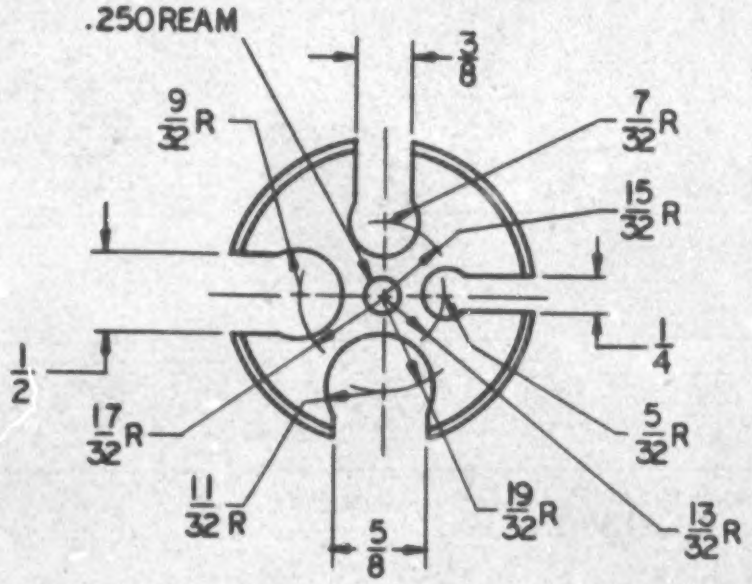


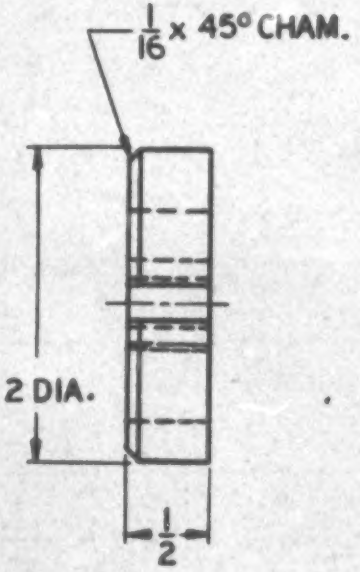
DIAMETRAL PITCH 12
LINEAR PITCH .262
DEPTH OF TOOTH .179

(5) RACK
MATL. C1020
1 REQD.

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	ARBOR PRESS	
SCALE: ——	GEAR SHAFT, RACK PAD, AND RACK	DWG. NO. 28





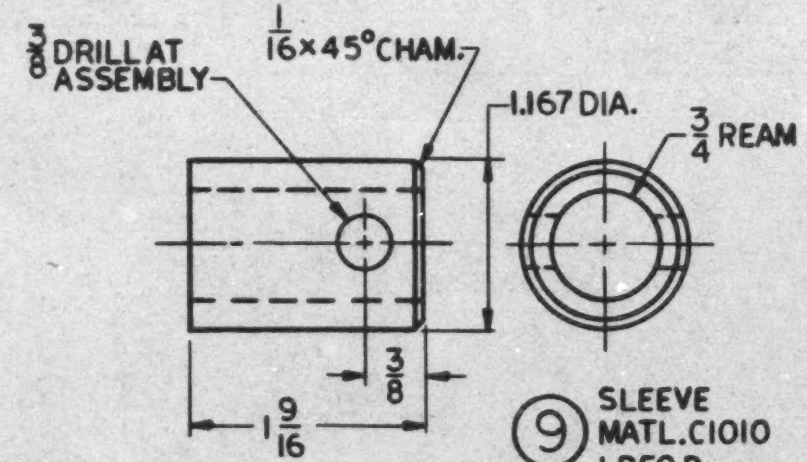
110

(12) MATL. C1020
1 REQ'D.

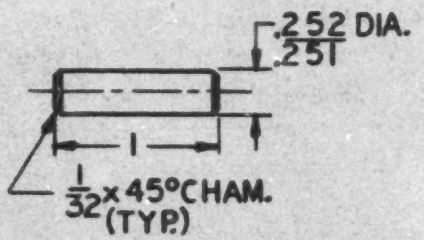
NOTE:
COUNTERSINK ALL HOLES TOP AND BOTTOM 1/32 DEEP BEFORE SLOTTING.

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS

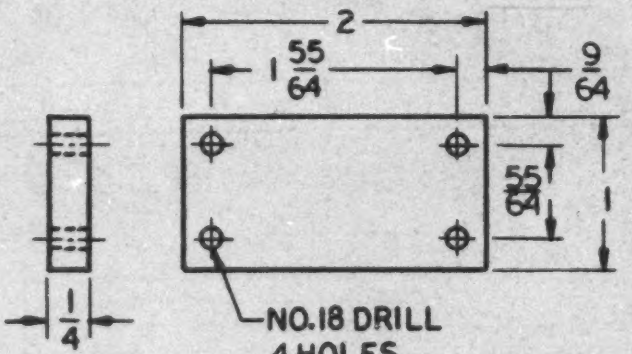
DRAWN BY: E.F.S.	ARBOR PRESS TABLE	
SCALE: ———		DWG. NO. 29



(9) SLEEVE
MATL. C1010
1 REQ D.



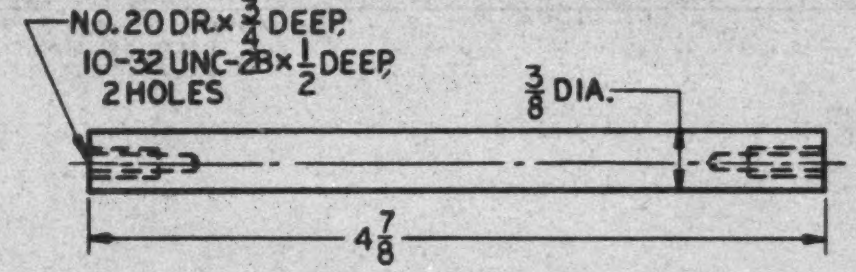
(10) TABLE PIN
MAT L. C1020
1 REQ D.



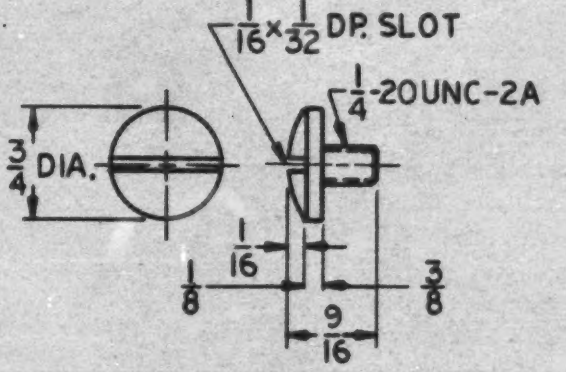
(11) COVER PLATE
MAT L. C1010
1 REQ D.

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS

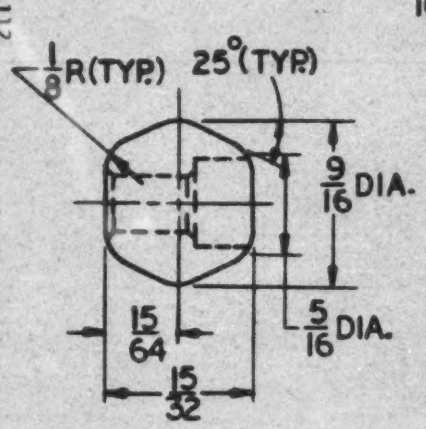
DRAWN BY: E.F.S.	ARBOR PRESS SLEEVE, TABLE PIN, AND COVER PLATE	
SCALE: ——		DWG. NO. 30

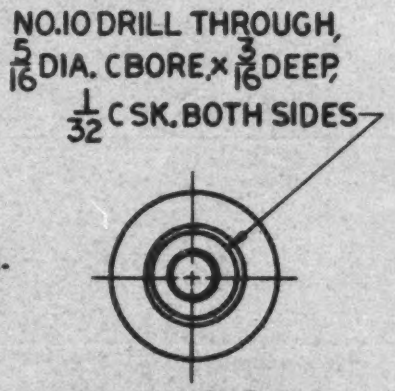


(7) HANDLE
MATL. C1020
1 REQD.



(8) GEAR SHAFT SCREW
MATL. C1020
1 REQD.

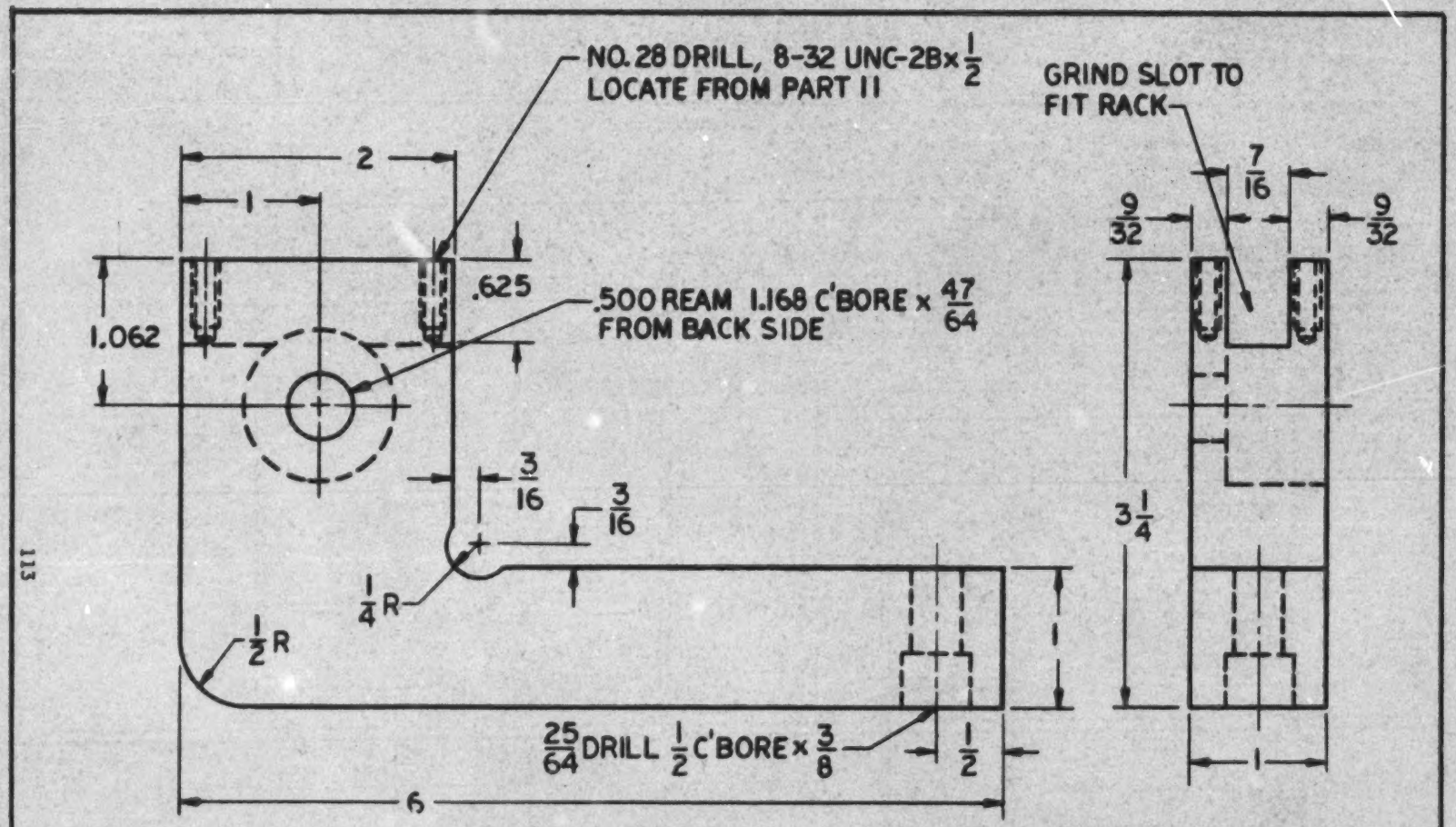




(6) HANDLE END
MATL. CRS
2 REQD.

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS

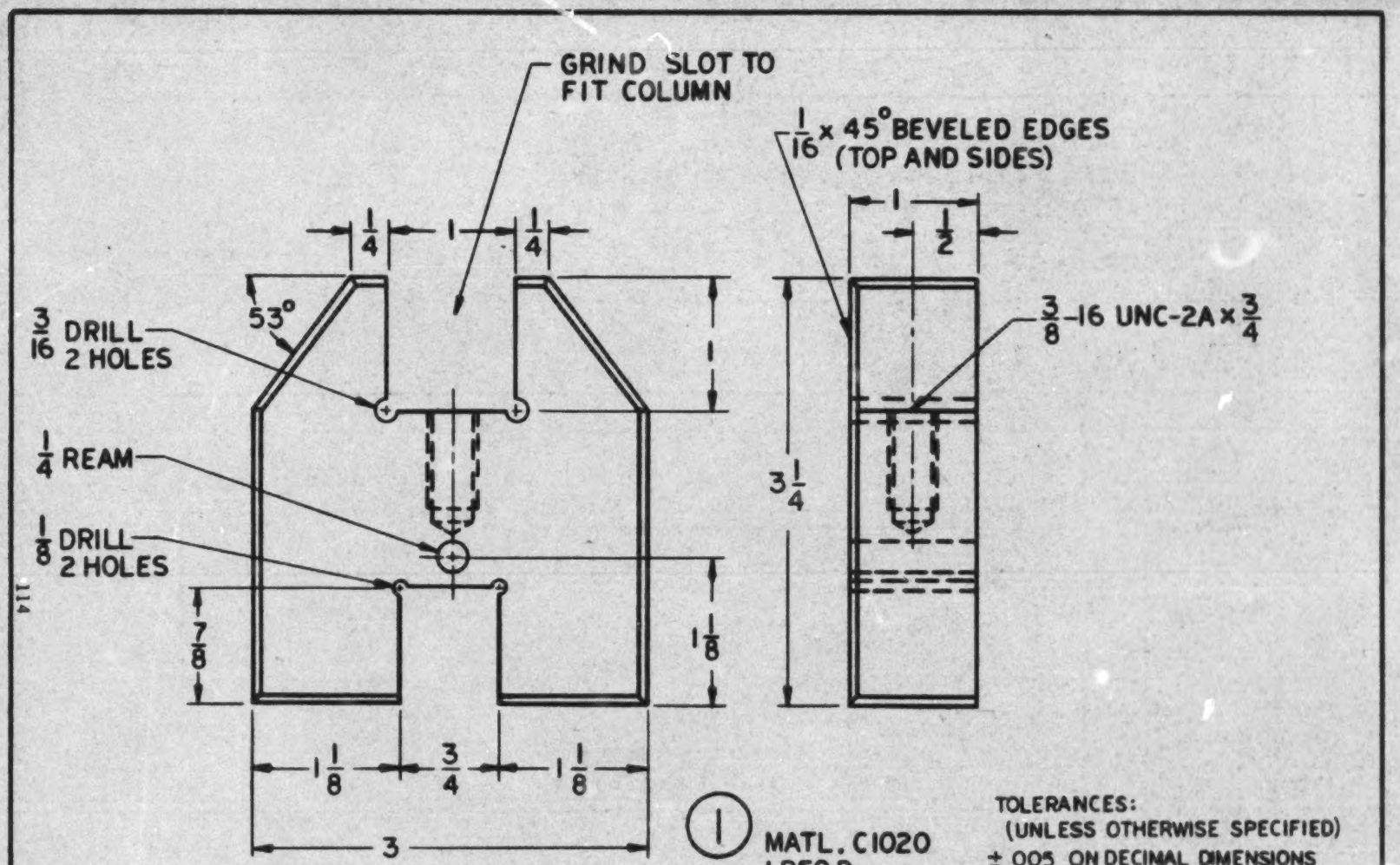
DRAWN BY: E.F.S.	ARBOR PRESS	
SCALE: —	HANDLE AND END	DWG. NO. 31

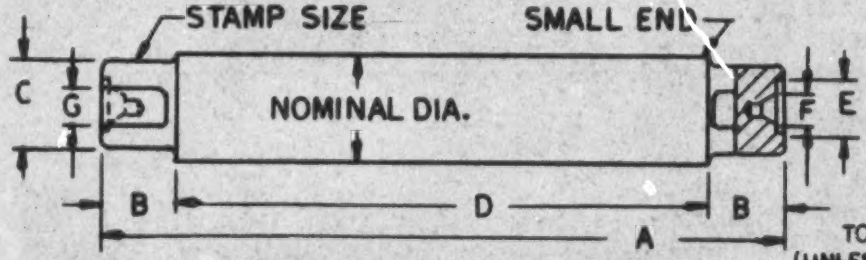


TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
± .005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
± 1° ON ANGULAR DIMENSIONS

(2)
MAT L. C1020
1 REQD.

DRAWN BY: E.F.S.	ARBOR PRESS COLUMN	
SCALE: ——		DWG. NO. 32


GRIND SLOT TO FIT COLUMN
1/16 x 45° BEVELED EDGES (TOP AND SIDES)
1/4
1
1/4
1
1/2
53°
3/16 DRILL 2 HOLES
3/8-16 UNC-2A x 3/4
1/4 REAM
1/8 DRILL 2 HOLES
3 1/4
7/8
1 1/8
1 1/8
3/4
1 1/8
3
1
MATL. C1020
1 REQ D.
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS
DRAWN BY: E.F.S.
SCALE: ——
ARBOR PRESS BASE
DWG. NO. 33

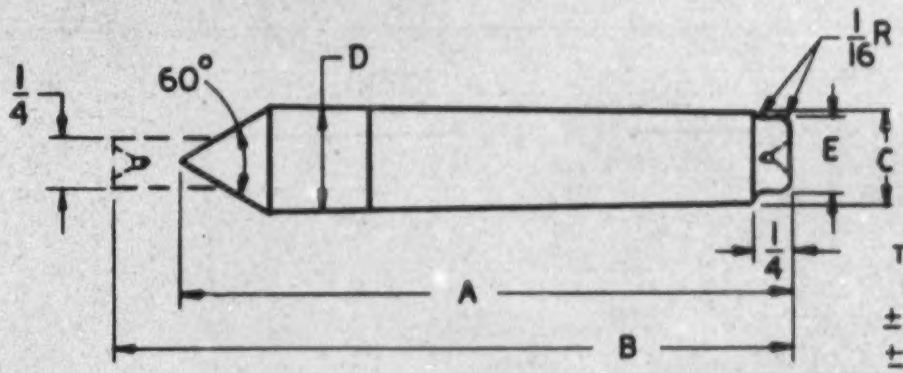


TAPER PER INCH .0005
DIAMETER OF SMALL END TO BE .0005 BELOW NOMINAL DIAMETER
ALLOW .025 ON NOMINAL DIA. FOR GRINDING

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

NOMINAL DIA.	A	B	C	D	E	F	G
3/16	3 5/8	5/8	5/32	2 5/8		5/64	1/8
1/4	3 7/8		7/32	2 7/8	11/64	1/8	5/32
5/16	4 1/8		9/32	3 1/8	7/32	5/32	3/16
3/8	4 1/4		11/32	3 1/4	1/4	7/32	7/32
7/16	4 1/2		13/32	3 1/2	1/4	7/32	1/4
1/2	5 1/8	5/8	15/32	3 7/8	5/16	7/32	1/4
9/16	5 3/8		17/32	4 1/8	5/16	7/32	9/32
5/8	5 1/2		19/32	4 1/4	17/32	1/4	9/32
11/16	6	3/4	21/32	4 1/2	3/8	1/4	5/16
3/4	6 1/8		23/32	4 5/8	7/16	1/4	5/16
13/16	6 1/4		25/32	4 3/4	13/32	5/16	5/16
7/8	6 3/8		27/32	4 7/8	17/32	5/16	3/8
15/16	6 1/2		29/32	5	9/16	5/16	3/8
1	7	7/8	31/32	5 1/4	9/16	5/16	3/8
1 1/2	7 1/4		1 1/16	5 1/2	9/16	5/16	3/8
1 1/4	7 1/2		1 3/16	5 3/4	5/8	3/8	7/16

DRAWN BY: E.F.S.	LATHE MANDREL	
SCALE: ——		DWG. NO. 34

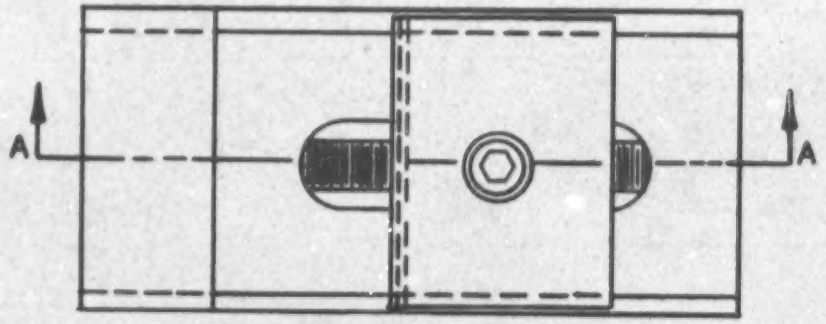


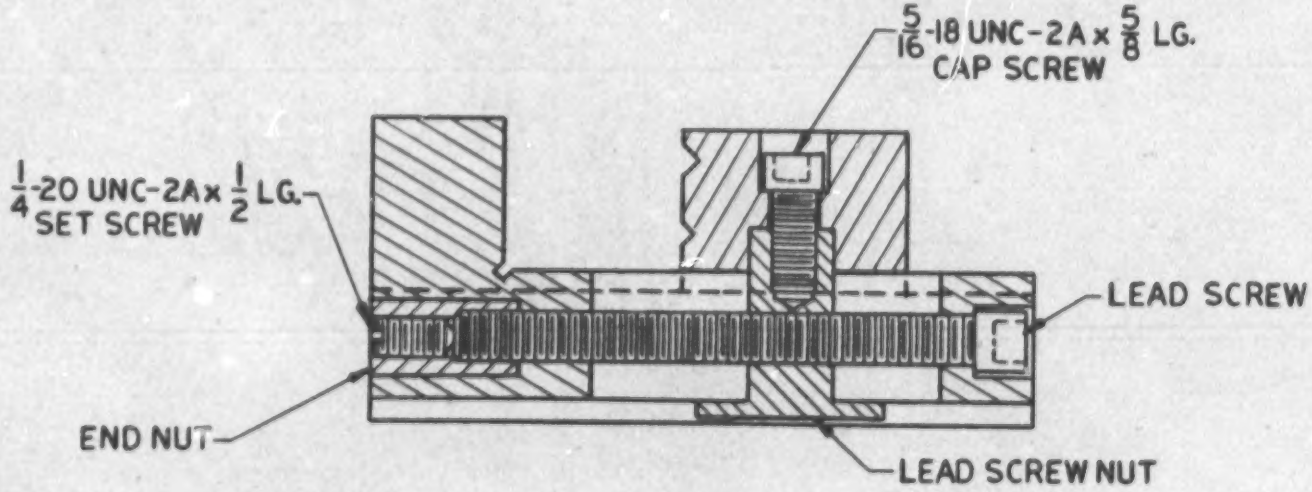
TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

MORSE TAPER	TAPER PER FT.	A	B	C	D	E
1	.598	3 1/8	3 5/8	.369	.475	.3125
2	.599	4 1/16	4 9/16	.572	.700	.500
3	.602	5 1/16	5 9/16	.778	.938	.625
4	.623	6 7/16	6 15/16	1.020	1.231	.750
5	.631	6 5/16	8 13/16	1.475	1.748	1.000
0	.6246	3 1/8	3 5/8	.252	.3561	.1875

NOTE:
ADD .025 TO DIMENSIONS C AND D FOR GRINDING.
MATERIAL: TOOL STEEL. HARDEN & DRAW.

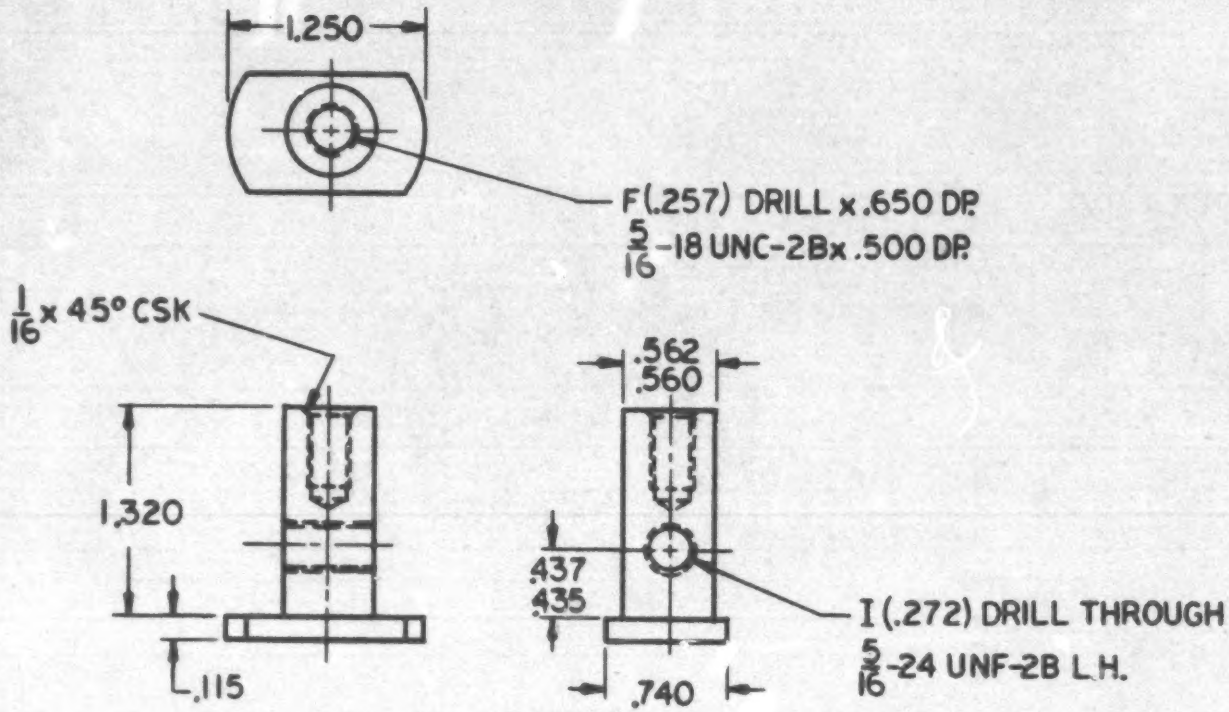
DRAWN BY: E.F.S.	LATHE CENTER, MORSE TAPER	
SCALE: ——		DWG. NO. 35





SECTION A-A

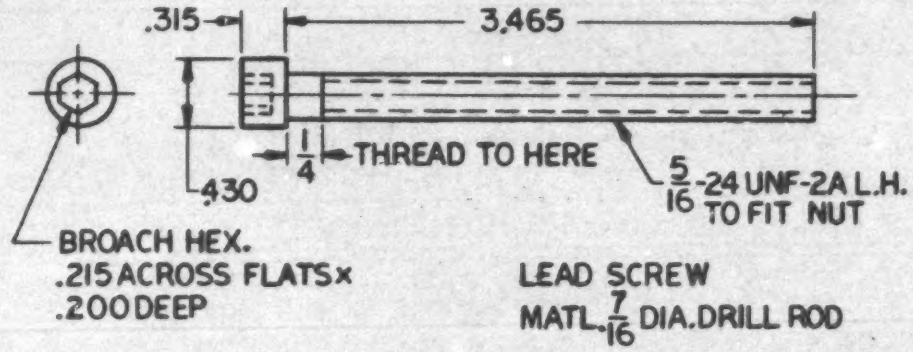
DRAWN BY: E.F.S.	GRINDING VISE ASSEMBLY	DWG. NO. 36
SCALE: ——		



LEAD SCREW NUT

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	GRINDING VISE:	
SCALE: ——	LEAD SCREW NUT	DWG. NO. 37



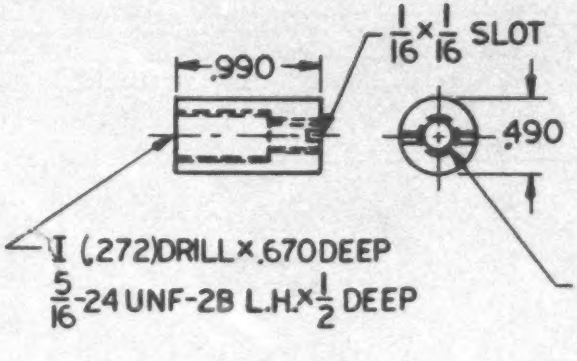
LEAD SCREW
MATL. 7/16 DIA. DRILL ROD

ADDITIONAL PARTS

SET SCREW 1/4-20 UNC-2A x 1/2 LG.

CAP SCREW 5/16-18 UNC-2A x 5/8 LG.

119



END NUT
MATL. 1/2 DRILL ROD HARDENED

TOLERANCES:
(UNLESS OTHERWISE SPECIFIED)
±.005 ON DECIMAL DIMENSIONS
± 1/64 ON FRACTIONAL DIMENSIONS
±1° ON ANGULAR DIMENSIONS

DRAWN BY: E.F.S.	GRINDING VISE LEAD SCREW AND END NUT	
SCALE: ——		DWG. NO. 38